PROGRAM MANAGER FOR
ROCKY MOUNTAIN ARSENAL

U.S. ARMY
MATERIEL COMMAND

— COMMITTED TO PROTECTION OF THE ENVIRONMENT —

FINAL
COMPREHENSIVE AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM AIR QUALITY DATA ASSESSMENT REPORT FOR FY 1993 VOLUME I of IV

VERSION 2.0

OCTOBER, 1994
CONTRACT NO. DAAA05-92-D-0002
TASK ORDER 92.10

EBASCO SERVICES INCORPORATED
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THE PURPOSE OF THE COMPREHENSIVE MONITORING AIR QUALITY AND METEOROLOGICAL MONITORING PROGRAM (CAQMMP) AT RMA IS TO CONTINUE THE ONGOING COLLECTION OF BASELINE DATA THAT WAS ESTABLISHED UNDER THE REMEDIAL INVESTIGATION (RI) PROGRAM AND THE COMPREHENSIVE MONITORING PROGRAM (CMP). TOGETHER, THESE PROGRAMS ARE USED TO DETERMINE AMBIENT AIR QUALITY IN SUPPORT OF REMEDIAL ACTIONS BEING CONDUCTED AT RMA. THIS REPORT FOCUSES ON RESULTS OF THE CAQMMP FOR FISCAL YEAR 1993 (FY93) AND INCLUDES ANALYSES AND COMPARISONS TO DATA FOR PRECEDING MONITORING PROGRAMS AT RMA AND FOR OTHER PROGRAMS THAT RAN CONCURRENTLY. THE CAQMMP FY93 DATA, IN CONJUNCTION WITH PREVIOUS CMP/CAQMMP DATA, BASIN F REMEDIAL MONITORING PROGRAM DATA, AND BASIN F POST REMEDIAL IRA F MONITORING PROGRAM DATA, PROVIDE A COMPREHENSIVE DATABASE FOR EVALUATING REMEDIAL PROGRESS RESULTING FROM THE BASIN F CLEANUP PROGRAM AND OTHER REMEDIAL ACTIVITIES. ONE OBJECTIVE OF THIS REPORT IS TO PROVIDE AN ASSESSMENT OF THE COMBINED DATABASE IN THE CONTEXT OF REMEDIAL PROGRESS. DATA ANALYSES CHARACTERIZED POTENTIAL SOURCES

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Prepared by:

EBASCO SERVICES INCORPORATED
AGEISS ENVIRONMENTAL INCORPORATED

Prepared for:

U.S. Army Program Manager's Office for
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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Atomic Absorption
ACGIH	American Council of Governmental Industrial Hygienists
ADI	Acceptable Daily Intake
Army	U.S. Army
As	Arsenic
Atrazine	2-chloro-4-ethylamino-6-isopropylamino-s-trianine
BCHPD	Bicycloheptadiene
BLDG	Building
°C	Degrees Celsius
C_6H_6	Benzene
CAQMMP	Comprehensive Air Quality and Meteorological Monitoring Program
CCl_4	Carbon Tetrachloride
ccm	cubic centimeters per minute
CDH	Colorado Department of Health
cfm	cubic feet per minute
CFR	Code of Federal Regulation
CH_2Cl_2	Methylene Chloride
$CHCl_3$	Chloroform
Chlordane	1,2,4,5,6,7,8,8-Octachloro-2,3,3a,4,7,7a-hexahydro-4,7-methano-1H-indene
ClC_6H_5	Chlorobenzene
CMP	Comprehensive Monitoring Program
CMP FY90	Comprehensive Monitoring Program Fiscal Year 1990
CO	Carbon Monoxide
CRL	Certified Reporting Limit
CVAAS	Cold Vapor Atomic Absorption Spectroscopy
DBCP	Dibromochloropropane
11DCLE	1,1-Dichloroethane
12DCLE	1,2-Dichloroethane
12DCE	trans-1,2-Dichloroethene
DCPD	Dicyclopentadiene
DIMP	Diisopropylmethyl phosphonate
12DMB	1,2-Dimethylbenzene
DMDS	Dimethyldisulfide
DMMP	Dimethylmethylphosphonate
DPS	Denver Public Schools
EA	Endangerment Assessment
EBASCO	Ebasco Services Incorporated
EPA	Environmental Protection Agency
ESH	Effective Stack Height
ETC_6H_5	Ethylbenzene

°F	Degrees Fahrenheit
FID	Flame Ionization Detector
FS	Feasibility Study
FY	Fiscal Year
GC	Gas Chromatograph
GC/MS	Gas Chromatography/Mass Spectrometry
GC/ECD	Gas Chromatography/Electron Capture Detection
GT	Greater Than
H_2S	Hydrogen Sulfide
HEAST	Health Effects Assessment Summary Table
Hg	Mercury
ICAP	Inductively Coupled Argon Plasma
IRA	Interim Reponse Action
IRA-F	Interim Response Action at Basin F
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
ISC	Industrial Source Complex Dispersion Model
lpm	liters per minute
m	meter
Malathion	S-[1,2-bis(ethoxycarbonyl)ethyl]0,0-dimethyl-phosphorodithioate
MEC_6H_5	Toluene
µg	micrograms
µg/std m^3	micrograms per standardized cubic meter of air (760 mm Hg, 25°C)
µg/m^3	micrograms per cubic meter
µm	micrometer (micron)
mg/m^3	milligrams per cubic meter
MIBK	Methyl Isobutyl Ketone
mph	miles per hour
MRI	Midwest Research Institute
MST	Mountain Standard Time
NAAQS	National Ambient Air Quality Standards
NAD	North American Datym
NATICH	National Air Toxics Information Clearinghouse
ng/m^3	nanograms per cubic meter
NH_3	Ammonia
NIOSH	National Institute of Occupational Safety and Health
NIST	Nation Institute of Standards and Technology
NMOC	Non Methane Organic Compound
NNDMEA	N-Nitrosodimethylamine
NO	Nitric Oxide
NO_2	Nitrogen Dioxide
NO_x	Nitrogen Oxides

LIST OF ACRONYMS AND ABBREVIATIONS (Cont.)

O_3	Ozone
OCP	Organochlorine Pesticides
OVA	Organic Vapor Analyzer
OVM	Organic Vapor Meter
Parathion	0,0-Diethyl-0(p-nitrophenyl)phosphorothioate
PID	Photoionization Detector
PM-10	Particulates less than 10 micrometers
PMRMA	Program Manager Rocky Mountain Arsenal
ppb	parts per billion
ppbr	parts per billion volume
PPDDE	2,2-Bis(4-chlorophenyl)-1,1-dichloroethylene
PPDDT	1,1-Bis(4-chlorophenyl)-2,2,2-trichloroethane
ppm	parts per million
PSD	Prevention of Significant Deterioration
PUF	Polyurethane Foam
QA	Quality Assurance
QC	Quality Control
RAP	Remedial Action Program
RBACs	Risk-Based Air Concentrations
RfCs	Reference Concentrations
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMA	Rocky Mountain Arsenal
SARA	Superfund Amendments and Reauthorization Act
sccm	standard cubic centimeters per minute (760 mm Hg, 25°C)
scfm	standard cubic feet per minute (760 mm Hg, 25°C)
SO_2	Sulfur Dioxide
SOP	Standard Operating Procedures
SQI	Submerged Quench Incinerator
Supona	2-chloro-1-(2,4-dichlorophenyl)vinyl diethyl phosphate
SVE	Soil Vapor Extraction
SVOC	Semivolatile Organic Compounds
111TCE	1,1,1-Trichloroethane
112TCE	1,1,2-Trichloroethane
TCLEE	Tetrachloroethene
TIC	Tentatively Identified Compound
TLV	Threshold Limit Value
tpy	tons per year
TRCLE	Trichloroethene
TSP	Total Suspended Particulates
UATMP	Urban Air Toxic Monitoring Program
UNK	Unknown Number

LIST OF ACRONYMS AND ABBREVIATIONS (Cont.)

USAEHA	U.S. Army Environmental Hygiene Agency
USATHAMA	U.S. Army Toxic and Hazardous Materials Agency
UTM	Universal Transverse Mercator
VOC	Volatile Organic Compounds
VOTA	Volatile Organic Toxic Air collection system (Graseby-Andersen, Inc., trade name
XAD	Adsorbent resin for semivolatile compounds (Supelco, Inc., trade name)
XYLENE	Total Xylenes
%	Percent

EXECUTIVE SUMMARY

The purpose of the Comprehensive Air Quality and Meteorological Monitoring Program (CAQMMP) at Rocky Mountain Arsenal (RMA) is to continue the ongoing collection of baseline data that was established under the Remedial Investigation (RI) Program and the Comprehensive Monitoring Program (CMP). Together, these programs are used to determine ambient air quality in support of remedial actions being conducted at RMA. The CAQMMP has several related key objectives: (1) the collection and verification of baseline and real-time air quality data for the purpose of meeting regulatory and compliance requirements; (2) the verification of progress that has been made to date in removing air contamination that resulted from previous activities; (3) the evaluation of progress that will be made in future remedial activities; (4) the provision of real-time guidelines, standard procedures, and data collection methods, as appropriate, to indicate impacts of ongoing remedial actions; (5) the provision of a rigorous and reliable database that can be used for assessment and litigation purposes; and (6) the determination as to whether potential contamination sources are on or off post. Finally, the CAQMMP provides technical support to the Remedial Investigation/Feasibility Study (RI/FS), the Interim Response Actions (IRAs), and the Endangerment Assessment (EA) at RMA.

The CAQMMP comprises a network of fixed, portable, and real-time air monitoring stations and instruments that collect samples and measure the following analytes:

- Total suspended particulates (TSP)
- Respirable particles less than 10 micrometers (PM-10)
- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Organochlorine pesticides (OCPs)
- Metals
- Arsenic (As)
- Mercury (Hg)

- Asbestos
- Carbon monoxide (CO)
- Nitric oxide (NO)
- Nitrogen dioxide (NO_2)
- Nitrogen oxides (NO_x)
- Ozone (O_3)
- Sulfur dioxide (SO_2)
- Hydrogen sulfide (H_2S)
- Ammonia (NH_3)

In addition, a four-station meteorological network monitors the following:

- Wind speed
- Wind direction
- Standard deviation of wind direction (sigma theta)
- Temperature
- Relative humidity
- Barometric pressure
- Solar radiation
- Precipitation

The program consists of several components: (1) year-round and routine seasonal baseline monitoring of TSP, PM-10, VOCs, SVOCs, OCPs, asbestos, specified metals, and gaseous pollutants; (2) "high-event" and/or contingency monitoring during specified meteorological conditions to measure peak concentrations of VOCs, SVOCs, OCPs, and metals; (3) quarterly

real-time monitoring of 115 Basin F cap and 126 waste pile cap sites, 25 waste pile vents, 4 Pond A vents, and 3 storage tank vent sites using a flame ionization detector (FID)-type organic vapor analyzer (OVA), a photoionization detector (PID)-type organic vapor meter (OVM), and real-time hydrogen sulfide and ammonia monitors as well as VOC sampling at the waste pile; (4) weekly testing of four ports in the Basin A Neck facility air stripper using OVA and OVM instruments, plus weekly and monthly VOC and SVOC sampling at the same locations; and (5) remediation monitoring coordination and direct support, as may be appropriate, to measure, standardize, and supplement on-site remedial and construction activities.

This report focuses on results of the CAQMMP for fiscal year 1993 (FY93) and includes analyses and comparisons to data for preceding monitoring programs at RMA and for other programs that ran concurrently. The CAQMMP FY93 data, in conjunction with previous CMP/CAQMMP data, Basin F Remedial Monitoring Program data, and Basin F post-remedial IRA-F Monitoring Program data, provide a comprehensive database for evaluating remedial progress resulting from the Basin F cleanup program and other remedial activities. One objective of this report is to provide an assessment of the combined database in the context of remedial progress.

Data analyses characterized potential sources for air contaminants that were observed, including both RMA and metropolitan Denver influences. On-site meteorological data were also used to describe those conditions associated with average and extreme events. Dispersion modeling was used as a tool to evaluate whether a source potentially contributed to observed ambient air concentrations.

The CAQMMP has remained a flexible and responsive program that addresses potential air quality concerns at RMA as remedial activities progress. For example, in FY93 the CAQMMP conducted intensive (every day and every third day) air monitoring in the vicinity of the pre-operational and later operational Submerged Quench Incinerator (SQI) facility. Special monitoring was also conducted to evaluate operations of the soil vapor extraction (SVE) system in the Motor Pool area, and special studies were conducted to evaluate VOC collection and

analyses methods. Finally, the CAQMMP participated in air quality monitoring planning for the proposed South Plants Pilot Demolition Program.

The following discussion summarizes the results of the analyses for each group of air quality parameters.

Total Suspended Particulates

TSP levels at RMA can be attributed to two principal sources: (1) the influx of particulate matter from metropolitan Denver, and (2) remedial activity sources which helped to produce windblown dust, particularly during very dry periods. There were no violations of the annual or 24-hour standards (which were temporarily suspended by the State of Colorado in July, 1993) at RMA during FY93. The distribution of the TSP concentration data clearly reflected the impact of Basin F remedial activities in FY88 and FY89 with dramatic decreases in TSP levels around Basin F after the conclusion of remedial activities. This feature has been observed in subsequent post-Basin F remedial monitoring, with occasional higher level TSP concentrations measured at other localized RMA remedial activities. In recent years, TSP levels have been highest at perimeter sites AQ1 and AQ2 (due to influx of particulates in urban air) and lowest at the RMA interior sites. Eastern perimeter site AQ4 has begun to show increasing TSP concentrations associated with the development of the new Denver International Airport and related vehicular traffic and construction activities.

Respirable Particles

Respirable particles, less than 10 micrometers in diameter (PM-10), are typically generated at RMA by dry windy conditions, but to a much lesser extent than for TSP. There were no violations of the annual or 24-hour PM-10 standards at RMA during FY93. Any high PM-10 levels at RMA could be related to relatively high PM-10 levels in metropolitan Denver. Remediation activities appear to play a minor role in increasing PM-10 levels during local remediation and construction activities. Nevertheless, the PM-10 network at RMA has been

expanded to better define PM-10 impacts associated with remediation activities. Similar to TSP, PM-10 impacts also decreased rapidly with distance from potential sources.

Volatile Organic Compounds

During the Basin F remediation, on-site activities appeared to be a source of several VOCs, including bicycloheptadiene, dimethyl sulfide, benzene, toluene, and ethylbenzene. One potential source of these compounds was the heavy equipment used during remediation. Chloroform was identified near both Basin F and South Plants. Levels of VOCs attributed to RMA sources during the Basin F remediation period decreased rapidly with distance from those sources, and levels at RMA boundaries were similar to or less than those within the urban environment of metropolitan Denver. During FY89, FY90, FY91, and FY92, monitored concentrations of many of the VOCs attributed to Basin F decreased significantly. During FY93, most of the VOC concentrations measured at RMA monitoring sites were attributed to close-by, off-post sources. However, some low-level residual VOCs have been measured in the vicinity of Basin F, Basin A, and South Plants.

Semivolatile Organic Compounds

Basin F appeared to be a source of several SVOCs, including aldrin, dieldrin, and endrin during the Basin F remediation period. The highest levels were detected in the immediate vicinity of Basin F during these remediation efforts. Results from a location downwind from the basin at the northeast perimeter of Basin F showed the highest levels of SVOCs, but at the RMA boundaries, these levels were reduced approximately to background levels. During the post-remediation periods, SVOC concentrations were reduced significantly in the vicinity of Basin F and all SVOC concentrations measured at other RMA monitoring sites were close to background levels. With the decrease of most SVOC concentrations to background levels, the monitoring of SVOCs (with the exception of high events) was limited to the organochlorine pesticide (OCP) subset during FY93.

Organochlorine Pesticides

Highest OCP levels were sampled during the Basin F remediation effort, and nearest to Basin F itself. Following the completion of the remedial activities, these levels were reduced significantly. OCP concentrations during FY93 were measured both at AQ8 (between South Plants and Basin A) and in the vicinity of Basin F. Concentrations were well below peak Basin F remediation levels. During FY93, these compounds were at or near the detection limit at the RMA boundary sites.

Metals

Ambient concentrations of metals across RMA were generally proportional to levels of TSP. In the past, maximum concentrations have been detected on high wind days and when there were high TSP and PM-10 levels (which in turn were attributed on occasion to sources off of RMA). During remediation activities, Basin F appeared to be a source of mercury, chromium, copper, and zinc, and these concentrations decreased rapidly with distance from Basin F. Following closure of the basin, the metals levels were reduced to those typical of baseline conditions. Isolated concentration maxima of chromium, cadmium, and copper have been measured during several post-Basin F remedial monitoring years. However, during FY93 metals levels at RMA mostly reflected the semi-urban baseline of the area. An exception was arsenic, which was measured on occasion at several RMA interior sites at slightly higher levels than typical background.

Asbestos

There were no detections of asbestos in FY93 which was also the case in FY88, FY90, and FY92. Asbestos was detected on only one day in FY89 and FY91.

Gaseous Criteria Pollutants

Ambient concentrations of the gaseous criteria pollutants, (i.e., sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone) were monitored continuously at RMA during FY93. Generally, the air quality at the interior RMA monitoring location was cleaner than that at other sites in the

Denver area. Criteria pollutant concentrations monitored within RMA showed no violations of any applicable short-term or long-term standards. Episodes with relatively high concentrations at RMA were related to potential nearby off-post sources under certain meteorological conditions. Most occurrences of relatively higher ambient concentrations within RMA appeared to be attributable to metropolitan Denver influences.

1.0 INTRODUCTION

The purpose of the Comprehensive Air Quality and Meteorological Monitoring Program (CAQMMP) at the Rocky Mountain Arsenal (RMA) is to continue the ongoing collection of baseline data that has been established under the Remedial Investigation (RI) Program and the Comprehensive Monitoring Program (CMP). These programs have been used to determine ambient air quality in support of remedial actions being conducted at RMA. The CAQMMP has several related key objectives: (1) the collection and verification of baseline and real-time air quality data for the purpose of meeting regulatory and compliance requirements; (2) the verification of progress that has been made to date in removing air contaminants resulting from previous activities; (3) the evaluation of progress that will be made in future remedial activities; (4) the provision of real-time guidelines, standard procedures, and data collection methods, as appropriate, to indicate impacts of ongoing remedial actions; (5) the provision of a rigorous and reliable database that can be used for assessment and litigation purposes; and (6) the determination as to whether potential contamination sources are on or off post. Finally, the CAQMMP provides technical support to the Remedial Investigation/Feasibility Study (RI/FS), the Interim Response Actions (IRAs), and the Endangerment Assessment (EA) at RMA.

The term CAQMMP will be used interchangeably with that portion of the program previously known as the CMP and the integrated CMP/Interim Response Action at Basin F (IRA-F) program that commenced on January 24, 1991.

This is the sixth CMP/CAQMMP report, and covers fiscal year 1993 (FY93). The FY91 and FY92 programs were augmented to include all previous CMP monitoring activities (with certain modifications), in addition to the IRA-F program, which incorporated more intensive monitoring in the vicinity of the Basin F remediation site. These practices have continued through the current FY93 CAQMMP.

The CAQMMP is comprised of a network of fixed, portable, and real-time air monitoring stations and instruments that collect samples and measure the following analytes:

- Total suspended particulates (TSP)
- Respirable particles less than 10 micrometers (PM-10)
- Volatile organic compounds (VOCs)
- Semivolatile organic compounds (SVOCs)
- Organochlorine pesticides (OCPs)
- Metals
- Arsenic (As)
- Mercury (Hg)
- Asbestos
- Carbon monoxide (CO)
- Nitric oxide (NO)
- Nitrogen dioxide (NO_2)
- Nitrogen oxides (NO_x)
- Ozone (O_3)
- Sulfur dioxide (SO_2)
- Hydrogen sulfide (H_2S)
- Ammonia (NH_3)

In addition, a four-station meteorological network monitors the following:

- Wind speed
- Wind direction
- Standard deviation of wind direction (sigma theta)

- Temperature
- Relative humidity
- Barometric pressure
- Solar radiation
- Precipitation

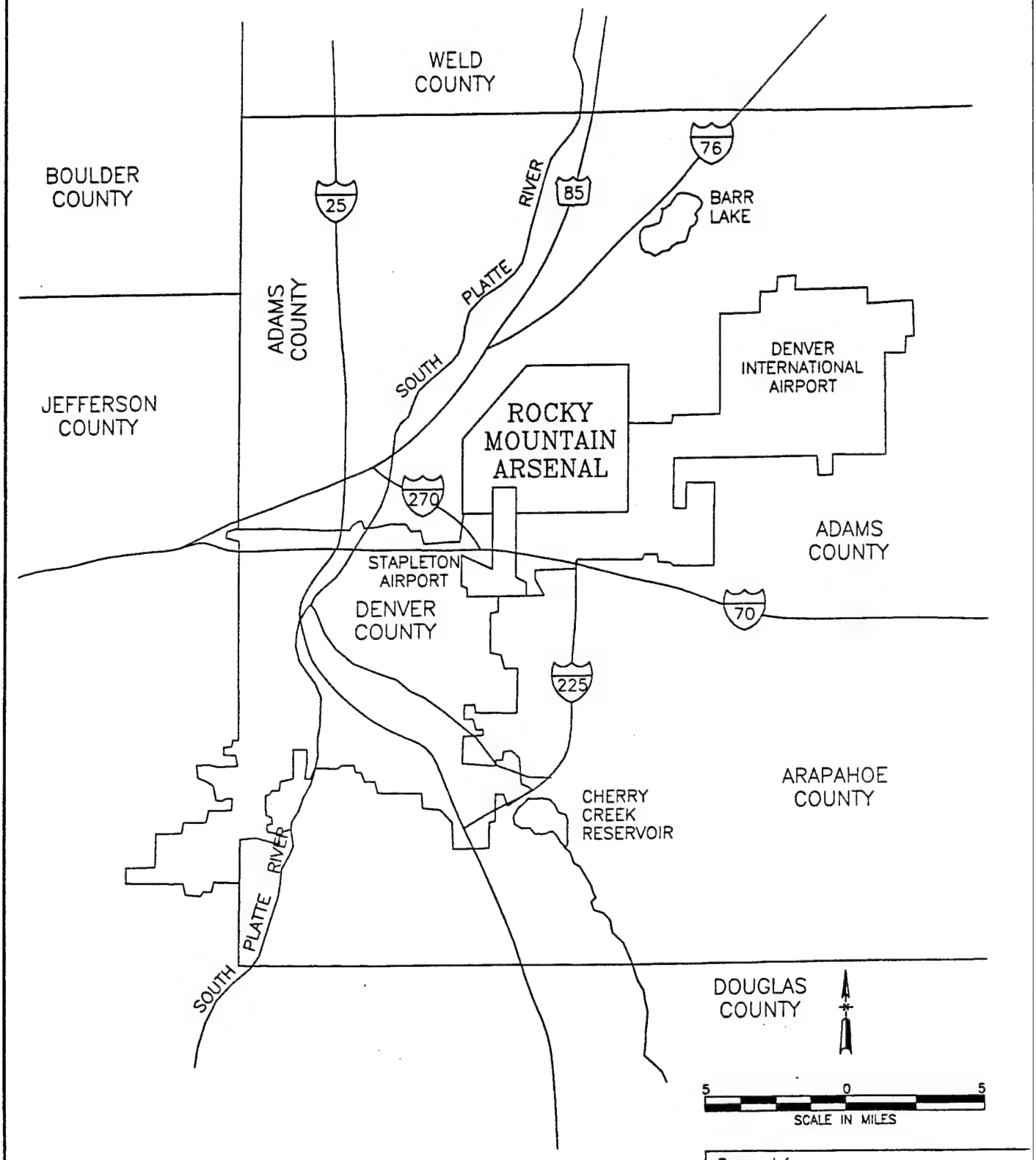
The program consists of several components: (1) year-round and routine seasonal baseline monitoring of TSP, PM-10, VOCs, SVOCs, OCPs, asbestos, specified metals, and gaseous criteria pollutants; (2) high-event and/or contingency monitoring during specified meteorological conditions to measure peak concentrations of VOCs, SVOCs, OCPs, and metals; (3) quarterly real-time monitoring of 115 Basin F cap and 126 waste pile cap sites, 25 waste pile vents, 4 Pond A vents, and 3 storage tank vent sites using a flame ionization detector (FID)-type organic vapor analyzer (OVA), a photoionization detector (PID)-type organic vapor meter (OVM), and real-time hydrogen sulfide and ammonia monitors; (4) weekly testing of four ports in the Basin A Neck facility air stripper using OVA and OVM instruments, plus weekly and monthly VOC and SVOC sampling at the same locations; and (5) remediation monitoring coordination and direct support, as may be appropriate, to measure, standardize, and supplement on-site remedial and construction activities. As examples, during the FY91 period, the CAQMMP assumed responsibility for IRA-F post-remedial monitoring in the vicinity of Basin F; this activity has continued in the FY92 and FY93 programs. During FY91, monitoring was conducted routinely upwind and downwind of the Submerged Quench Incinerator (SQI) facility during its construction. During FY93, when the SQI was completed and operations were initiated, the CAQMMP conducted intensive (daily and every third day) monitoring in order to evaluate potential impacts. These activities illustrate the responsive and flexible nature of the program. Finally, the program provides for the integration and evaluation of all collected baseline and site-specific data for use in planned remedial actions and for the assessment of the progress of remedial activities. For example, during FY93, the CAQMMP participated in air quality monitoring planning for the South Plants Pilot Demolition Program.

1.1 SITE BACKGROUND INFORMATION

RMA occupies more than 17,000 acres (27 square miles) northeast of Denver, Colorado in western Adams County (Figure 1.1-1). It was established in 1942, and was used to manufacture chemical and incendiary munitions, and to demilitarize chemical munitions. Additionally, industrial chemicals were manufactured at RMA from 1947 to 1982. A number of manufacturing, storage, and transportation facilities were built and used throughout the years to support RMA activities. These identifiable RMA features were naturally perceived as potential contaminant sources, and their names along with the names of local geographic features are frequently used in discussing specific RMA areas (Figure 1.1-2). The history of RMA operations from the initiation of manufacturing in 1942 to the cessation of activities has been discussed in detail in the previous CMP/CAQMMP reports.

1.2 POTENTIAL CONTAMINANT SOURCES

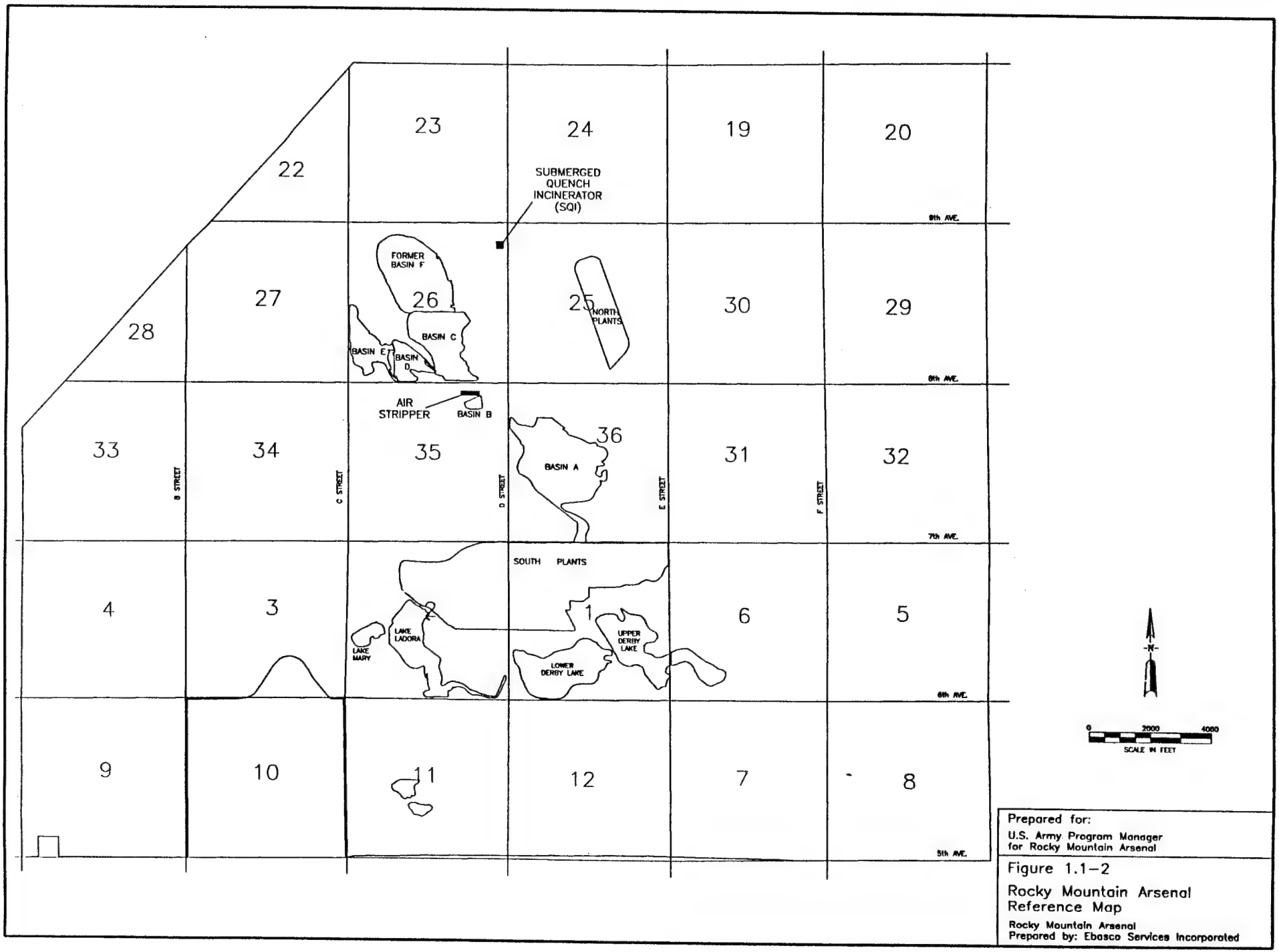
Potential sources of airborne contaminants within RMA boundaries have been identified and air quality and meteorological monitoring sites have been located near them, as shown in Figure 1.2-1. Previous air monitoring studies and remedial investigations conducted at RMA indicated that major sources of potential airborne emissions exist from the South Plants area, through Sections 36 and 26, to Basin F. Because production and demilitarization activities have ceased, there are no longer discrete or point sources of emissions at RMA. Rather, the sources shown in Figure 1.2-1 are large area or fugitive sources whose emissions are a function of atmospheric conditions, surface cover, and the contaminants' physical state. These sources, under typical conditions, do not appear to pose a major problem; however, remediating these sources may create temporary problems with air quality. These conditions are being monitored under the CAQMMP. An example of this is the Basin F Interim Action Remedial Cleanup Program. Although the liquid from Basin F has been removed and no longer represents an uncontrolled source of several potential contaminants, air monitoring has continued in the vicinity of Basin F under the CMP, the Basin F post-remedial IRA-F Monitoring Program, and the present CAQMMP. The location of the initial Basin F source has been maintained in the various figures

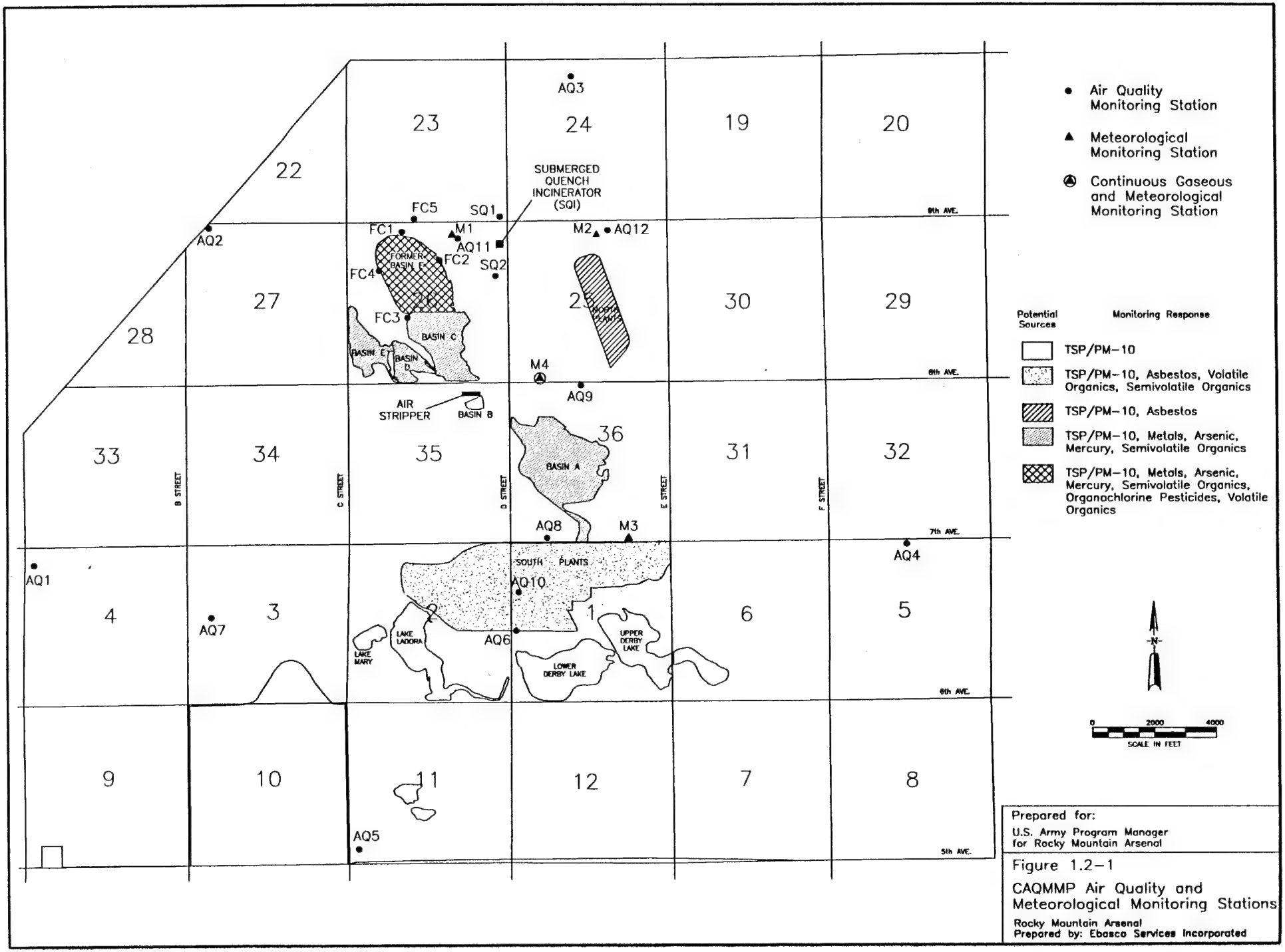


Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 1.1–1
Rocky Mountain Arsenal
Location Map

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated


22
23
24
19
20
SUBMERGED QUENCH INCINERATOR (SQI)
9th AVE.
28
27
FORMER BASIN F
26
25
NORTH PLANTS
30
29
BASIN C
BASIN E
BASIN D
8th AVE.
AIR STRIPPER
BASIN B
33
34
35
36
31
32
BASIN A
B STREET
C STREET
D STREET
E STREET
F STREET
7th AVE.
SOUTH PLANTS
4
3
2
1
6
5
LAKE LADORA
LAKE MARY
UPPER DERBY LAKE
LOWER DERBY LAKE
6th AVE.
9
10
11
12
7
8
5th AVE.
-N-
0
2000
4000
SCALE IN FEET
Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal
Figure 1.1-2
Rocky Mountain Arsenal
Reference Map
Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



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U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 1.2-1

CAQMMP Air Quality and Meteorological Monitoring Stations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

shown in this report in order to better depict possible continuing impacts and remedial progress as a result of the cleanup activities.

Based on historical records of disposal activities and chemical spills, the following general areas have been suspected as potential sources of fugitive airborne emissions during the previous CMP/CAQMMP (FY88 through FY93) monitoring periods:

- South Plants manufacturing complex—VOCs, SVOCs, and asbestos
- Basin A—SVOCs, metals, and TSP
- Basin F—VOCs, SVOCs, metals, and TSP

During CAQMMP FY93, routine and high-event monitoring were conducted at each of these locations.

1.3 FINDINGS OF THE AIR REMEDIAL INVESTIGATION PROGRAM AND THE COMPREHENSIVE MONITORING PROGRAM

As noted in the introduction to this section, the CAQMMP continues the ongoing collection of air quality baseline data first initiated under the 12-month Air RI, the results of which are contained in the Air RI report (ESE 1988).

The CMP, which was a continuation of the Air RI, has been in continuous operation since 1988 (for FY93, it has been designated the CAQMMP). A summary of the findings of this program, which encompasses approximately 5 years (through FY92), is presented below.

Total Suspended Particulates

TSP levels at RMA can be attributed to two principal sources: (1) the influx of particulate matter from the Denver metropolitan area, and (2) remedial activity sources that help to produce windblown dust, particularly during very dry episodes. The TSP data clearly reflect the impact of Basin F remedial activities (FY88 and FY89), with dramatic decreases in TSP levels around

Basin F after the conclusion of remedial activities. During FY90 and FY91, other construction activities at RMA, such as in the vicinity of the Lower Derby Lake spillway, produced noticeable TSP impacts; again these were highly localized and decreased rapidly from the source. In addition, there were several episodes during which impacts from the Denver metropolitan area completely overwhelmed impacts from potential on-post sources. This was especially noticeable at the RMA western and southern TSP sampling sites. At the eastern and northern boundaries of RMA, the TSP levels were well below those of the Denver metropolitan area, and were more representative of rural conditions. Some increase in TSP concentrations was noted in FY92 at the eastern perimeter of RMA, possibly associated with increased vehicular traffic associated with construction activities at the new Denver International Airport.

Respirable Particles

PM-10 are generated at RMA by dry, windy conditions, but to a much lesser extent than for TSP. Over the past 5 years there have been limited or no violations of the annual or 24-hour PM-10 standards measured at RMA. Higher PM-10 levels at RMA could generally be associated with the relatively high PM-10 levels found in the Denver metropolitan area. Remedial activities appeared to play a minor role in increasing PM-10 levels; however, the PM-10 network during the early years of the program was not extensive around potential PM-10 sources associated with remediation activity. Impacts also decreased rapidly with distance from potential sources.

Metals

Ambient concentrations of metals across RMA were generally proportional to levels of TSP. Maximum concentrations were detected during high-wind events and also when there were high TSP and PM-10 levels, which in turn were attributed to off-post sources. During remedial activities, Basin F appeared to be a source of mercury, chromium, copper, and zinc, and these concentrations decreased rapidly with distance from Basin F. Following closure of the basin, the metals levels were reduced to those typical of baseline conditions. For example, during FY92 isolated concentration maxima of chromium, cadmium, and copper, relative to average

post-remedial concentrations, were measured which did not appear to be directly attributable to RMA sources (WCC 1993).

Asbestos

There were no detections of asbestos during FY88, FY90, and FY92, and there were only 2 days with detections during FY89 and FY91; results confirm that there is no evident source of ambient asbestos fibers on RMA.

Volatile Organic Compounds

During the Basin F remediation, on-post activities appeared to be a source of several VOCs, including bicycloheptadiene, dimethyl disulfide, benzene, toluene, and ethylbenzene. Some of these emissions could have resulted from the emissions from heavy equipment used during remediation. Chloroform was identified near both Basin F and South Plants. Levels of VOCs that were attributed to RMA sources during the Basin F remediation period decreased rapidly with distance from those sources, and levels at RMA boundaries were similar to or less than those within the urban environment of metropolitan Denver. During FY89 and FY90, many of the VOCs attributed to Basin F decreased significantly. During FY90, FY91, and FY92, many of the VOCs measured at RMA monitoring sites were attributed to proximal off-post sources.

Semivolatile Organic Compounds

Basin F appeared to be a source of several SVOCs, including aldrin, dieldrin, and endrin, during the Basin F remediation period. The highest levels were detected in the immediate vicinity of Basin F. Results from a location downwind from the basin at the northeast perimeter of Basin F, showed the highest levels of SVOCs, but at RMA boundaries these levels were reduced to approximately background levels. During the post-remedial action periods, SVOC concentrations were reduced significantly in the vicinity of Basin F and all SVOC concentrations measured at other CMP monitoring sites were close to background levels or below laboratory detection limits.

Organochlorine Pesticides

Highest OCP levels were sampled during the Basin F remediation effort and nearest to Basin F itself. Following the completion of the remedial activities, these levels were reduced to slightly above background levels in the vicinity of Basin F as well. Some higher OCP concentrations during FY90, FY91, and FY92 were measured at AQ3, suggesting a possible primary source north of RMA, with potential impacts also from Basin F based on prevailing wind patterns (WCC 1993). During FY92, concentrations of 2,2-Bis(4-chlorophenyl)-1,1-dichloroethylene (PPDDE) and 2,2-Bis(4-chlorophenyl)-1,1,1-tricloroethane (PPDDT) were higher at site FC1 than previously observed during post-remedial phases. These concentrations were still, however, significantly lower than levels measured during remedial activities.

Criteria Gaseous Pollutants

Ambient concentrations of the criteria gaseous pollutants (sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone) have been monitored continuously at RMA from FY88 through FY92. Generally, the air quality at the RMA monitoring location was cleaner than that at other sites in the Denver area. Criteria pollutant concentrations monitored within RMA showed no violations of any applicable short-term or long-term standards. Episodes with relatively high concentrations at RMA were related to potential nearby sources under certain meteorological conditions. Most occurrences of relatively higher ambient concentrations within RMA appeared to be attributable to metropolitan Denver influences.

2.0 REGIONAL AND LOCAL AIR QUALITY AND METEOROLOGICAL CHARACTERISTICS

2.1 AIR QUALITY

The Denver metropolitan area has experienced chronic air quality problems in recent years. During stagnant and/or air inversion conditions, ozone and carbon monoxide concentrations sometimes create extremely poor air quality. This problem has generally been associated with motor vehicles, although air pollution also comes from a wide variety of industrial sources located in the Denver area. Major sources include power plants, oil refineries and transfer stations, chemical plants, cement plants, and various agricultural operations. In addition to these sources, substantial emissions occur as a result of wood burning. Considerable background air quality information for criteria pollutants influencing the RMA area is provided by the Colorado Department of Health (CDH)(CDH 1984, 1985, 1986, 1987, 1988, 1989, 1990, 1991, 1993). Table 2.1-1 shows applicable CDH and National Ambient Air Quality Standards (NAAQS) for criteria pollutants.

A more detailed discussion of the status of criteria pollutants (those airborne contaminants for which the U.S. Environmental Protection Agency [EPA] has established NAAQS values in the Denver metropolitan area and in the vicinity of RMA) is provided in the following sections.

2.1.1 Particulate Matter

Particulate matter (primary and secondary) in the atmosphere is a contributing factor to the visibility-related problems in both urban and rural areas. In Denver this is commonly known as the "brown cloud" or, more appropriately, the "Denver haze" because it is frequently not brown nor is it actually a cloud. The sources of airborne particles are many: blown dust and sand from roadways, fields, and construction, or coal dust, fly ash, and carbon black from various combustion sources including automobile exhaust. Two increasing sources of particulate matter that could have a major impact on haze problems are diesel-powered mobile sources and wood burning. These sources emit potentially significant amounts of elemental and organic carbon particles that play a major role in producing haze-related phenomena, including adverse health

Table 2.1-1 National Ambient Air Quality Standards (NAAQS) and Colorado Standards Page 1 of 1

Pollutant	Averaging Time*	NAAQS	Colorado Standard
Carbon Monoxide (CO)			
Primary	1-hour	35 ppm (40 mg/m^3)	same as NAAQS
Primary	8-hour	9 ppm (10 mg/m^3)	same as NAAQS
Ozone (O_3)			
Primary and Secondary	1-hour	0.12 ppm (235 $\mu g/m^3$)	same as NAAQS
Nitrogen Dioxide (NO_2)			
Primary and Secondary	Annual Arithmetic Mean	0.053 ppm (100 $\mu g/m^3$)	same as NAAQS
Sulfur Dioxide (SO_2)			
Primary	24-hour	0.14 ppm (365 $\mu g/m^3$)	**
Primary	Annual Arithmetic Mean	0.03 ppm (80 $\mu g/m^3$)	**
Secondary	3-hour	0.50 ppm (1300 $\mu g/m^3$)	0.27 ppm (700 $\mu g/m^3$)**
Particulate Matter Less than 10 Micrometers (PM-10)			
Primary and Secondary	24-hour	150 $\mu g/m^3$	same as NAAQS
Primary and Secondary	Annual Arithmetic Mean	50 $\mu g/m^3$	same as NAAQS
Total Suspended Particulates (TSP)			
Primary	24-hour	None	260 $\mu g/m^3$***
Secondary	24-hour	None	150 $\mu g/m^3$***
Primary	Annual Geometric Mean	None	75 $\mu g/m^3$***
Secondary	Annual Geometric Mean	None	60 $\mu g/m^3$***
Lead (Pb)			
Primary and Secondary	Calendar Quarter	1.5 $\mu g/m^3$	1.5 $\mu g/m^3$(monthly)

Source: Colorado Department of Health, 1993, and 40 CFR Part 50, Sections 50.1 - 50.12.

* Standards other than annual averages are not to be exceeded more than once per year.

** In addition to the 3-hour Colorado standard, incremental standards above baseline are established for 3-hour, 24-hour, and annual averaging periods for Category I, II, and III areas.

*** The Colorado standards for TSP were suspended for one year effective August 30, 1993.

ppm - parts per million
$\mu g/m^3$ - micrograms per cubic meter
mg/m^3 - milligrams per cubic meter
Primary - standard intended to protect public health
Secondary - standard intended to protect public welfare

effects. TSP range in size from less than 0.1 micrometer (μm) to 50 μm; larger particles tend to settle out of the air. Gaseous emissions that form secondary particles, fuel combustion from stationary sources, and motor vehicle emissions also are contributors to the urban haze problem.

2.1.1.1 Total Suspended Particulates

EPA uses primary standards to define levels of air quality that are protective of public health, and uses secondary standards to define levels of air quality that are protective of the public welfare from any known or anticipated adverse effects of a pollutant (40 CFR Part 50) (CFR 1985). With respect to particulate matter, EPA has removed the standard for TSP and redefined the criteria for suspended particulates as PM-10 (particles less than 10 micrometers). The State of Colorado maintained the TSP standard for several years awaiting more definitive evaluation concerning the consequences of EPA's action, but in June 1993 the Colorado Air Quality Control Commission suspended the Ambient Standard for Total Suspended Particulates for a period of 1 year through August 30, 1994. It is anticipated that the Commission will make a determination as to eventual termination or revision of the standard at a later date.

Because of the indefinite status of the TSP standard, and also because 11 of the 12 sampling months of the CAQMMP FY93 period were conducted while the standard was still in effect, this report will continue to reference the suspended particulate standard for TSP. For the purpose of record, the primary Colorado standard for TSP, independent of particle size or chemical composition, was as follows: the long-term standard was an annual geometric mean not to exceed 75 micrograms of particulate matter per cubic meter of air ($\mu g/m^3$); the short-term standard was a 24-hour average of 260 $\mu g/m^3$ not to be exceeded more than once per year. The 24-hour secondary TSP standard was 150 $\mu g/m^3$, which was not to be exceeded more than once per year; the annual geometric mean secondary standard was 60 $\mu g/m^3$.

In addition, it is important to note that the CAQMMP has employed 12 or more sampling locations for TSP for the past 6 years, and while a formal regulatory standard may or may not exist, the TSP data have been a strong indicator of RMA remedial activity and remedial progress;

as such, TSP data will continue to be a significant tool for evaluating important assessment criteria pertaining to ambient air quality.

Historical data (1974 to 1984) for Denver in the vicinity of RMA show an average TSP value of 97 $\mu g/m^3$. Studies conducted by the Army in 1969 at the RMA boundary show a 24-hour maximum value of 274 $\mu g/m^3$ and annual geometric means ranging from 24 to 72 $\mu g/m^3$ (USAEHA 1969).

During FY92, the latest official data available (CDH 1993), maximum 24-hour TSP levels at the downtown Denver Continuous Air Monitoring Program (CAMP) site reached 379 $\mu g/m^3$ and the maximum annual geometric mean was 120 $\mu g/m^3$. Preliminary results for FY93 indicate that the maximum 24-hour contribution was 610 $\mu g/m^3$ and the annual geometric mean was 155 $\mu g/m^3$ in downtown Denver. Several intense inversion episodes occurred in this winter period that will be discussed further in Section 4.2.

There are a number of major stationary sources in the vicinity of RMA with TSP emissions of 25 tons per year (tpy) or more. Several of the sources are located within 2 miles to the west and southwest of RMA and contribute a large portion of the total TSP (as well as PM-10) emissions for Adams, Arapahoe, and Denver Counties (CDH 1990). Compared to these sources, RMA accounts for a small fraction of the total TSP emissions for the metropolitan area. In addition to these external stationary sources, dust from vehicle traffic and off-road sources contributes greatly to the TSP emissions.

TSP monitoring as part of the Air RI was conducted from June 1986 to June 1987 under Task 18 (Contract No. DAAK-11-84-D-0016) at 12 fixed sampling stations within RMA. The data collected at all sites were in compliance with both the primary and secondary NAAQS except for one 24-hour sample (151 $\mu g/m^3$) near South Plants. This compares to the 24-hour secondary standard of 150 $\mu g/m^3$. The highest annual geometric mean TSP level was 55 $\mu g/m^3$ at the west boundary, while the lowest was 34 $\mu g/m^3$ at the interior of the site.

As previously noted, CAQMMP monitoring of TSP levels at RMA has indicated two principal sources: the influx of airborne particulate matter from the Denver metropolitan area, and windblown dust generated during the conduct of remedial activities, especially during very dry episodes. CAQMMP monitoring stations AQ1, AQ2, and AQ5 on the southern and western boundaries of RMA (see Figure 1.2-1) have consistently measured the highest long-term concentrations (annual geometric mean), while those sites immediately downwind from remediation activities, in particular Basin F, reflected the highest short-term (24-hour) concentrations. At the conclusion of the Basin F remedial activity, TSP levels decreased significantly at monitoring stations surrounding Basin F. It should be noted that periods of intense remedial activity at RMA will continue to produce maximum short-term (24-hour) concentrations and the CAQMMP is specifically designed to measure the impact of such activity. FY93 RMA TSP results are provided in Section 4.2.

2.1.1.2 Respirable Particles (PM-10)

EPA and CDH recently have revised the particulate standards to account for the deeper inhalability of smaller particles. The new standards, rather than applying to TSP, apply to particles less than 10 μm in diameter (referred to as PM-10). The primary standards are an annual arithmetic average of 50 $\mu g/m^3$ and a 24-hour average of 150 $\mu g/m^3$.

During 1992, the highest PM-10 levels in the metropolitan area surrounding Denver were reported at the Adams City site; the maximum 24-hour PM-10 value was 183 $\mu g/m^3$ and the annual average was 38 $\mu g/m^3$. This may be the result of industrial activity in this portion of the metropolitan area, or of prevailing southerly winds blowing particulate matter accumulated in the central portions of Denver to the northern portions of the city. A more intensive effort is currently in progress by CDH to obtain further information on PM-10 levels in the Denver metropolitan area. Preliminary results indicate that during 1993 the maximum 24-hour PM-10 value collected at the Adams City site (4301 E. 72nd Avenue) was 183 $\mu g/m^3$, while the maximum 24-hour value in downtown Denver was 176 $\mu g/m^3$.

PM-10 levels were monitored during the 1986 – 1987 Air RI near Basin A at three air quality sampling stations: two at the RMA boundaries and one at the interior. PM-10 levels were highest at the boundary stations and lowest at the interior station. The arithmetic mean values ranged from 18 $\mu g/m^3$ at Basin A to 36 $\mu g/m^3$ at the northwest boundary. Individual 24-hour values ranged from 5 to 94 $\mu g/m^3$, with lowest levels at the interior of RMA and higher levels at the boundary. During the CMP/CAQMMP, respirable particles, as in the case of TSP, could be attributed to two principal sources: (1) the influx of urban air from metropolitan Denver, and (2) remediation activities producing windblown dust. It appeared that PM-10 impacts from remedial activities occurred to a lesser extent than TSP impacts; however, this may be a result of a more sparse network of PM-10 stations in proximity to intense remedial activities. As a result, the PM-10 network has been increased under the FY93 CAQMMP to a total of 13 samplers (from an original total of five samplers). FY93 CAQMMP PM-10 monitoring results are provided in Section 4.3.

2.1.2 Metals

Airborne metals that exist primarily as particulate matter may be inhaled and can cause adverse health effects. One of these metals is lead, which exists in the atmosphere and is predominantly produced by vehicles that burn leaded gasoline. Lead is the only metal that is a criteria pollutant according to EPA. The current federal standard for lead is not to exceed 1.5 $\mu g/m^3$, averaged over a 3-month (calendar quarter) period. The Colorado standard is 1.5 $\mu g/m^3$, averaged over a 1-month period. The average concentration in FY93 in downtown Denver (CAMP site) was 0.05 $\mu g/m^3$ and the maximum 24-hour value was 0.24 $\mu g/m^3$. At 5400 N. Washington St. in Adams County, where extensive daily metals monitoring was conducted in FY93, the average lead concentration was 0.09 $\mu g/m^3$ and the 24-hour maximum level was 1.0 $\mu g/m^3$. At this site, arsenic measured an average level of 0.01 $\mu g/m^3$ and a maximum value of 0.07 $\mu g/m^3$; the cadmium average concentration was 0.06 $\mu g/m^3$ and the maximum value was 2.03 $\mu g/m^3$.

Historical data in the vicinity of RMA for lead indicate concentrations of 0.5 to 1.0 $\mu g/m^3$, although there has been a significant decline realized in the last 10 years with the introduction

of lead-free gasoline. In general, lead ambient concentrations in recent years, both in metropolitan Denver and RMA, have seen reductions by a factor of 10 or more. The Army monitored lead concentrations at the boundary of RMA and at the interior of the site in 1980, and the average concentrations ranged from .13 to .26 micrograms per cubic meter ($\mu g/m^3$) (USAEHA 1981). Lead and other metals were monitored during the 1986 – 1987 Air RI. Samples were taken on high-event (high wind) days at approximately 10 locations. Lead values were generally less than 0.1 $\mu g/m^3$. Other metals (mercury, arsenic, cadmium, chromium, copper, and zinc) were also detected at typical urban metals concentrations; cadmium and copper were detected at slightly higher levels near the basins. Zinc levels were typical of urban environmental levels, except for one event in which concentrations were in excess of 10 $\mu g/m^3$. The Air RI report states that the zinc levels for this day may be suspect as low levels were detected at all other events. Metals measured under the CAQMMP at RMA were proportional to the levels of TSP; maximum contributions occurred on high wind days and also on days when high TSP and PM-10 levels were measured. During remedial activities, Basin F appeared to be a source of mercury, chromium, copper, and zinc; these concentrations decreased rapidly with distance from Basin F. Following closure of the basin, the levels of metals were typical of baseline conditions. During the CAQMMP FY93 period, all metal levels were well below toxic guidelines. CAQMMP metals results are provided in Section 4.4.

2.1.3 Sulfur Dioxide

Sulfur dioxide is considered to be one of the major pollution problems worldwide. It is emitted mainly from stationary sources that burn fossil fuels. There are two existing primary NAAQS for sulfur dioxide: (1) an annual arithmetic average of 0.03 parts per million (ppm); and (2) a 24-hour average standard where concentrations are not to exceed 0.14 ppm more than once per year. The current secondary NAAQS for sulfur dioxide is a 3-hour average concentration of 0.5 ppm, not to be exceeded more than once per year. Colorado has a more restrictive secondary 3-hour standard of 0.27 ppm. In Denver, the maximum 3-hour value in FY93 was 0.175 ppm; the maximum 24-hour contribution was 0.081 ppm; and the annual arithmetic mean was 0.009 ppm. They were all measured downtown at the CAMP site at 21st Street and Broadway (CDH 1993).

Background data from the Army's 1969 air monitoring program show a maximum value of 0.10 ppm for sulfur dioxide which was measured on the western boundary of RMA when the wind was blowing in a northeasterly direction (USAEHA 1969). Because most sulfur dioxide values were less than detection limits at all stations, the Army reported geometric means of 0 $\mu g/m^3$ at each of the nine stations. Currently, there are no significant sources of sulfur dioxide within RMA. In FY93, the annual arithmetic mean from the RMA monitoring site for sulfur dioxide was 0.002 ppm.

2.1.4 Nitrogen Oxides

Nitrogen in the air combines with oxygen during high-temperature combustion producing oxides of nitrogen (NO_X). Most of the nitrogen oxides emitted are nitric oxide (NO). Nitrogen dioxide (NO_2) is formed generally from the oxidation of the more commonly emitted nitric oxide. Nitrogen dioxide is the predecessor of gaseous nitric acid and nitrate aerosols. The relationship between nitrogen oxides and the resultant ambient nitrogen dioxide, nitric acid, and nitrate aerosol concentrations is neither direct nor constant. About 44 percent of the emissions of nitrogen oxides in the Denver metropolitan area come from large combustion sources such as power plants; 33 percent from motor vehicles; 15 percent from space heating; 3 percent from aircraft; and 5 percent from miscellaneous off-road vehicles. The current standard for nitrogen dioxide is an annual arithmetic mean value not to exceed 0.053 ppm.

No violations of the nitrogen dioxide standard have been recorded in Colorado in recent years. Data from 1969 Army monitoring stations show a 24-hour maximum value of 0.075 ppm at the southern boundary of RMA (USAEHA 1969). During FY93, nitrogen dioxide ambient concentrations for the annual period ranged from 0.022 ppm at the Welby site (closest CDH site to RMA) to 0.037 ppm at the CAMP site at 21st street and Broadway. At RMA, the annual mean for FY93 was 0.018 ppm or 34 percent of the federal and state standard of the 0.053 ppm annual arithmetic mean.

2.1.5 Ozone

The poor air quality of the Denver metropolitan area is generally blamed on carbon monoxide, although the area is still classified as a nonattainment area for ozone. Ozone is not emitted directly from a source, as are other pollutants, but forms as a secondary pollutant in a complex photochemical process in the atmosphere. Precursors of ozone are certain reactive hydrocarbons and nitrogen oxides that react chemically in sunlight to form ozone. The reactive hydrocarbons are emitted in automobile exhaust, from gasoline and oil storage and transfer operations, and from industrial usage of paint solvents, degreasing agents, cleaning fluids, ink solvents, incompletely burned coal or wood, and many other sources. Plants also emit some reactive hydrocarbons; for example, terpenes are released from pine trees.

Although ozone production is a year-round phenomenon, the highest ozone levels generally occur during the summer season. Strong sunlight and stagnant meteorological conditions can cause reactive pollutants to remain in an area for several days. Ozone produced under these conditions can be transported many miles outside the urban environment.

The current ozone standard is 0.12 ppm averaged over 1 hour (CDH 1993). North Denver has been classified as a nonattainment area for ozone because this area had not previously complied with the NAAQS. The maximum 1-hour ozone level reported at 78th and Steele streets in 1986 was 0.162 ppm; the second maximum 1-hour value was 0.134 ppm. During FY93, the maximum 1-hour concentration was 0.087 ppm. The ozone standard has not been exceeded in the Denver metropolitan area since 1989.

Ozone monitoring was only implemented at RMA in 1989. In FY93, the maximum 1-hour ozone concentration measured at the RMA criteria pollutant site was 0.099 ppm.

2.1.6 Carbon Monoxide

Urban atmospheres contain about 100 times as much carbon monoxide as any other pollutant. Urban carbon monoxide is produced primarily by motor vehicles. In the Denver metropolitan

area, it is estimated that 86 percent of the carbon monoxide emissions in 1988 were from vehicular sources during the winter season. The remainder originated from other sources of combustion such as heating, incineration, and power generation.

Because motor vehicle emissions are the major source of carbon monoxide, daily concentration peaks coincide with morning and evening rush hours. The worst carbon monoxide problems are found where large numbers of slow-moving cars congregate, such as in large parking lots or during traffic jams. Carbon monoxide can accumulate temporarily to harmful levels, especially in calm weather during autumn and winter, when automobile emissions and fuel combustion for space heating reach their peak. Carbon monoxide problems are worse in winter because: (1) cold weather makes motor vehicles run less efficiently; (2) more combustion for space heating is required; and (3) on winter nights, a strong inversion layer develops near the ground, trapping the pollutants.

A relatively new source of carbon monoxide has been introduced into metropolitan areas in Colorado in recent years. The large-scale use of wood in air-tight stoves for home heating could contribute up to 7 percent of the total urban carbon monoxide concentrations (CDH 1990).

There are two current standards for carbon monoxide: 9 ppm averaged over an 8-hour period, and 35 ppm averaged over a 1-hour period; these levels are not to be exceeded more than once per year. The overall trend for carbon monoxide pollution in the Denver metropolitan area appears to be improving (although inversion variations from year to year may be exacerbating factors). The area experienced ten 8-hour violations of the standard in FY93; these all occurred during an intense inversion period in early December 1992, which will be discussed subsequently in this report.

The Denver metropolitan area is classified as a nonattainment area for carbon monoxide because the NAAQS for this pollutant has been routinely exceeded. It is noted that because of the nonattainment status of carbon monoxide in the Denver metropolitan area, emissions above

significant levels require off-set procedures under EPA's New Source Review regulations. The NAAQS and Colorado Ambient Air Quality Standards for both the 1-hour and 8-hour averages were never exceeded at RMA during the FY93 collection period. During FY93 at RMA, the maximum observed 1-hour concentration was 7.7 ppm, and the maximum 8-hour concentration was 4.3 ppm; both occurred in December, 1992.

2.1.7 Criteria Pollutants at RMA

Ambient concentrations of the criteria pollutants (sulfur dioxide, nitrogen dioxide, carbon monoxide, and ozone) have been monitored continuously at RMA since FY89. Generally, the air quality at the RMA monitoring location has been cleaner than that at other sites in the Denver metropolitan area. The RMA data showed no violations of any short- or long-term standards for these pollutants. Episodes with relatively high concentrations at RMA were related to nearby sources in the metropolitan area under certain meteorological conditions. Several of these have been specifically related to typical Denver "brown cloud" conditions and have been previously discussed in these reports. FY93 CAQMMP criteria pollutant results are provided in Section 5.

2.1.8 Volatile Organic Compounds

RMA has been identified as a source of several VOCs, especially during remedial activities. During the Basin F cleanup, on-site remedial activities appeared to be a source for bicycloheptadiene, dimethyl disulfide, benzene, toluene, and ethylbenzene. Some of these ambient concentrations may have resulted from the emissions of heavy equipment that were used during remedial activity.

Many of the VOC levels measured at RMA interior locations during FY89 and FY90 (the Basin F remediation period) were below Denver metropolitan and other urban ambient levels. Those compounds that were observed at higher levels during remedial activities decreased to at or below typical urban VOC background levels during the post-remedial monitoring periods (RLSA 1990b, WCC 1993). VOC levels measured at the RMA monitoring sites during the post-remediation period may be partially attributed to some residual emissions in the Basin F area as

well as to emissions from the undisturbed areas of the South Plants, Basin A, and the North Plants. However, it would appear that VOC ambient levels measured at RMA through the post Basin F remedial period were for the most part dependent upon off-post sources and upon varying wind and inversion conditions.

VOC sources (in excess of 10 tpy) include several major industries (Sundstrand Aviation, Pillow Kingdom, Gates Rubber Company, Samsonite Corporation, Conoco Denver Refinery) as well as many smaller industrial operations, chemical plants, paint manufacturing facilities, and large gasoline service stations. In addition, there are a large number of VOC point sources below 10 tpy in the Denver metropolitan area including dry cleaning establishments, paint stores, automobile shops, and small service stations. More importantly, many VOC emissions in the area are from mobile sources including gasoline and diesel burning vehicles, construction equipment, and aircraft from nearby Stapleton International Airport. It is estimated that non-stationary sources represent a significant portion of the total VOC emissions.

It is difficult to characterize toxicity effects strictly by tonnage of emissions. Obviously, some constituents react differently in ambient air and represent greater toxicity hazards than others. Denver metropolitan VOC emission sources are listed and discussed in further detail in Section 4.6.6 of this report. One of the important tasks of the CAQMMP is to delineate off-post sources from potential on-post sources. This is accomplished through a comprehensive air quality and meteorological monitoring network and through other strategies such as high-event monitoring, contingency monitoring, mobile monitoring, and real-time monitoring (see Section 3).

2.2 METEOROLOGY AND AIR QUALITY DISPERSION

The RMA area is generally classified as mid-latitude and semiarid. This indicates an area with hot summers, cold winters, and relatively light rainfall. Mean maximum temperatures range from 43 degrees Fahrenheit (°F) in January to 88°F in July. The mean minimum temperature for January is 16°F; in July it is 59°F. Precipitation in the general region ranges from 12 to 16 inches per year, with approximately 80 percent falling between April and September. Snow and

sleet usually occurs from September to May, with the heaviest snowfall in March and possible trace accumulations as late as June. Thunderstorms occur frequently in the region. They are accompanied generally by heavy showers, severe, gusty winds, and frequent thunder and lightning with occasional hail. Pertinent meteorological summaries for the RMA vicinity (from Stapleton International Airport) are shown in Tables 2.2-1, 2.2-2, 2.2-3, and 2.2-4.

Wind directional frequencies reflect the drainage of the South Platte River valley, which slopes gradually from south to north. Typically, surface winds in the area flow downslope (south to north) during the night and upslope (north to south) during the daytime, resulting in a north-south bimodal distribution, as illustrated in the wind rose for the Stapleton International Airport (Figure 2.2-1). As the RMA area is on higher sloping terrain to the east of the South Platte River Valley, there is slight variation from Stapleton International Airport, reflected in a moderate easterly flow drainage component. Winds from all directions at moderate speeds will also occur under varying synoptic conditions. The windy months (with gusts as high as 72 miles per hour) are March and April. These winds are generally from the south-southwest. These months come immediately after the driest months of the year (November through February), and have the highest potential for dust storms. Section 6.0 presents additional wind data.

Dispersion of pollutants is the result of varying meteorological influences. Early morning inversions over the Denver metropolitan area are common and occasionally persist throughout the day. This prevents mixing of the atmospheric boundary layer and causes accumulation of pollutants. During nearly 60 percent of the year, Denver experiences stable atmospheric conditions that favor air pollution events. The majority of stable conditions are observed during the winter.

Another factor that contributes to high air pollution in Denver is the daily back-and-forth motion of air along the Front Range. As noted, the Denver metropolitan area is in the South Platte River basin, with decreasing elevation toward the north through northeast. Cold, heavy air drains downslope at night and during the early morning hours. As the atmosphere warms during the

Table 2.2-1 Summary of Temperature Data in the Rocky Mountain Arsenal Vicinity

Month	Temperatures							Mean Number of Days			
	Average			Extreme				Max.		Min.	
	Daily Maximum	Daily Minimum	Monthly	Record Highest	Year	Record Lowest	Year	90°F & above	32°F & below	32°F & below	0°F & below
January	43.1	15.9	29.5	73	1982	-25	1963	0	6	30	4
February	46.9	20.2	33.6	76	1963	-30	1936	0	4	26	2
March	51.2	24.7	38.0	84	1971	-11	1943	0	3	25	1
April	61.0	33.7	47.4	90	1992	-2	1975	<1	<1	11	<1
May	70.7	43.6	57.2	96	1942	22	1954	<1	0	2	0
June	81.6	52.4	67.0	104	1936	30	1951	6	0	0	0
July	88.0	58.7	73.4	104	1939	43	1972	15	0	0	0
August	85.8	57.0	71.4	101	1938	41	1964	9	0	0	0
September	77.5	47.7	62.6	97	1960	17	1985	2	<1	1	0
October	66.8	36.9	51.9	89	1991	3	1969	0	<1	9	0
November	52.4	25.1	38.8	79	1990	-8	1950	0	2	24	<1
December	46.1	18.9	32.5	75	1980	-21	1990	0	5	29	3
Annual	64.3	36.2	50.3	104	July 1939	-30	Feb. 1936	33	22	156	9
Length of Record (years)	121	121	121	58	58	58	58	32	32	32	32

Source: 1992 Local Climatological Data, Annual Summary with Comparative Data, Denver, Colorado

°F - Degrees Fahrenheit

Table 2.2-2 Summary of Precipitation and Humidity Data in the Rocky Mountain Arsenal Vicinity

Month	Water Eqivalent							Snow, ice pellets				Relative Humitity (%)			
	Average	Maximum Monthly (inches)	Year	Minimum Monthly (inches)	Year	Maximum 24 hrs. (inches)	Year	Maximum Monthly (inches)	Year	Maximum 24 hrs.	Year	05 hr. (local time)	11 hr. (local time)	17 hr. (local time)	23 hr. (local time)
January	0.51	1.44	1948	0.01	1952	1.02	1962	24.3	1992	14.5	1992	63	45	49	63
February	0.69	1.66	1960	0.01	1970	1.01	1953	18.3	1960	9.5	1953	67	44	44	65
March	1.21	4.56	1983	0.13	1945	2.79	1983	30.5	1983	18.0	1983	68	42	40	62
April	1.81	4.17	1942	0.03	1963	3.25	1967	28.3	1935	17.3	1957	67	38	35	58
May	2.47	7.31	1957	0.06	1974	3.55	1973	13.6	1950	10.7	1950	70	39	38	61
June	1.58	4.69	1967	0.09	1960	3.16	1970	0.3	1951	0.3	1951	70	37	35	59
July	1.93	6.41	1965	0.17	1939	2.42	1965	T	1992	T	1992	69	35	34	57
August	1.53	5.85	1979	0.06	1960	3.43	1951	T	1991	T	1991	70	37	35	59
September	1.23	4.67	1961	T	1944	2.44	1936	21.3	1936	19.4	1936	69	37	34	59
October	0.98	4.17	1969	0.05	1962	1.71	1947	31.2	1969	12.4	1969	65	36	35	59
November	0.82	2.97	1946	0.01	1949	1.29	1975	39.1	1946	15.9	1983	68	44	49	65
December	0.55	2.84	1973	0.03	1977	2.00	1982	30.8	1973	23.6	1982	65	45	52	64
Annual	15.31	7.31	May 1957	T	Sept 1944	3.55	May 1973	39.1	Nov 1946	23.6	Dec 1982	68	40	40	61
Length of Record (years)	58	58	58	58	58	58	58	58	58	58	58	32	32	32	32

Source: 1992 Local Climatological Data, Annual Summary with Comparative Data, Denver, Colorado

T = trace amount
% = percent
hr = hour

Table 2.2-3 Summary of Wind and Pressure Data in the Rocky Mountain Arsenal Vicinity

Month	Wind					Average Station Pressure (mb)
	Through 1963		Fastest observed 1 minute			
	Mean Speed (mph)	Prevailing Direction	Speed (mph)	Direction	Year	Barometer Elevation (5,287 ft msl)
January	8.6	S	44	NNE	1982	834.7
February	8.8	S	36	NNE	1989	834.7
March	9.7	S	41	NNE	1991	832.1
April	10.0	S	41	NE	1987	833.6
May	9.3	S	43	NE	1983	834.3
June	8.8	S	38	NNE	1987	836.5
July	8.3	S	37	NNE	1982	838.9
August	8.0	S	33	NNE	1989	839.1
September	7.9	S	36	NNE	1988	838.5
October	7.8	S	36	N	1992	837.8
November	8.3	S	36	NE	1987	835.3
December	8.4	S	38	NNE	1981	834.9
Annual	8.7	S	44	NNE	Jan 1982	835.9
Length of Record (years)	44		11		11	20

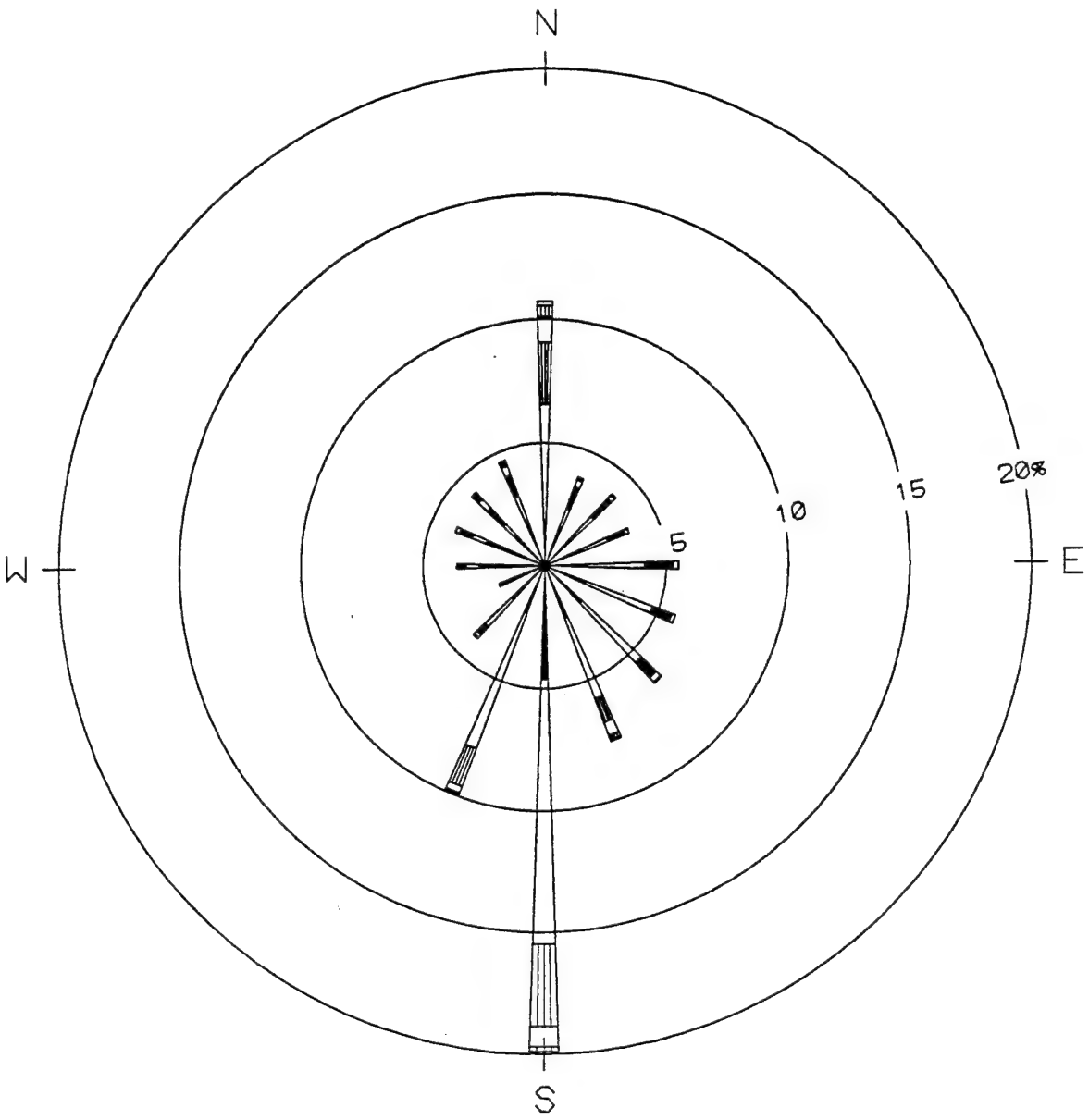
Source: 1992 Local Climatological Data, Annual Summary with Comparative Data, Denver, Colorado

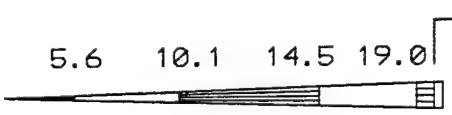
mb millibars
ft msl feet above mean sea level
mph miles per hour

Table 2.2-4 Summary of Meteorological Data in the Rocky Mountain Arsenal Vicinity

Month	Percent of Possible Sunshine	Mean Sky Cover, Tenths, Sunrise to Sunset	Mean Number of Days: Sunrise to Sunset: Clear	Partly Cloudy	Cloudy	Precipitation 0.01 inch or More	Snow, Ice Pellets 1.0 inch or More	Thunderstorms	Heavy Fog, Visibility 1/4 Mile or Less
January	71	5.5	10	9	12	6	2	<1	1
February	70	5.9	8	9	12	6	2	<1	2
March	69	6.2	8	10	13	9	4	<1	1
April	67	6.1	7	11	13	9	3	2	1
May	64	6.2	6	12	13	11	<1	6	1
June	70	5.1	10	12	8	9	0	10	<1
July	71	5.0	9	16	6	9	0	11	<1
August	72	5.0	10	14	8	9	0	8	1
September	74	4.4	13	9	8	6	<1	3	1
October	72	4.5	13	9	9	5	1	1	1
November	64	5.5	10	10	10	6	3	<1	1
December	67	5.3	11	10	11	5	3	0	1
Annual	69	5.4	115	130	120	89	18	42	10
Length of Record (years)	43	44	58	58	58	58	58	58	52

Source: 1992 Local Climatological Data, Annual Summary with Comparative Data, Denver, Colorado





WIND SPEED CLASS BOUNDARIES
(MILES/HOUR)

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 2.2–1
Denver/Stapleton Airport
Wind Rose for 1988–1992

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

afternoon, the flow reverses sharply, and much of the air that had traversed the city earlier going downslope as clean air re-enters Denver as polluted air going upslope.

Because Denver is at a high altitude, the atmosphere is thin, allowing more ultraviolet radiation to interact with airborne contaminants. Chemical reactions initiated by photochemical processes increase Denver's smog problem, particularly haze. More detailed evaluations relating meteorological connections at RMA to the dispersion of atmospheric pollutants will be discussed in subsequent sections of this report.

3.0 PROGRAM STRATEGY AND METHODOLOGY

3.1 GENERAL BACKGROUND

The procedures for air sample collection and analysis are described in detail in the CAQMMP Draft Technical Work Plan (Technical Plan) (EBASCO 1992). The methods for meteorological data collection are also contained in the Technical Plan. This section provides a brief overview of the sampling and analysis program with emphasis on field activities accomplished during the FY93 CAQMMP. The Technical Plan provides a flexible vehicle for upgrading CAQMMP monitoring requirements and techniques as experience is gained and as remedial programs continue. For example, past modifications included the addition of continuous gaseous monitoring (ozone, carbon monoxide, sulfur dioxide, and nitrogen oxides) and the incorporation of a four-tower meteorological monitoring network. During FY91, all IRA-F monitoring sites were included in the CMP, as well as cap and vent monitoring at the Basin F waste pile, tank farm, and pond vents. During FY92, the CMP also conducted air monitoring of off-gases from the air stripper located within the Basin A Neck groundwater intercept facility, and monitoring for TSP, PM-10, metals, VOCs, and OCPs upwind and downwind of the proposed SQI. During FY93, the CAQMMP provided an intensive air monitoring program upwind and downwind of the operational SQI facility, and provided special air monitoring for the Soil Vapor Extraction System (SVE) activities. In FY93, the CAQMMP conducted special studies to improve the effectiveness of VOC sampling, including comparisons between the use of Tenax/charcoal tubes (Method TO-1) and passivated canisters (see Sections 4.6.8 and 4.6.9).

During the FY93 CAQMMP, the following parameters were sampled:

1. Air Quality
   - Total suspended particulates (TSP)
   - Respirable particulates (PM-10)
   - Asbestos
   - Volatile organic compounds (VOCs)
   - Semivolatile organic compounds (SVOCs)
   - Organochlorine pesticides (OCPs)

- Total organics (using OVA and OVM monitors)
- Metals (cadmium, chromium, copper, lead, and zinc)
- Arsenic (As)
- Mercury (Hg)
- Sulfur dioxide (SO_2)
- Carbon monoxide (CO)
- Ozone (O_3)
- Nitric oxide (NO)
- Nitrogen dioxide (NO_2)
- Nitrogen oxides (NO_x)
- Hydrogen sulfide (H_2S)
- Ammonia (NH_3)

2. Meteorology
   - Wind speed
   - Wind direction
   - Standard deviation of wind direction (sigma theta)
   - Temperature
   - Barometric pressure
   - Precipitation
   - Humidity
   - Solar radiation

3.2 AIR QUALITY MONITORING PROGRAM

This section presents justification for selection of sample locations and parameters monitored, as well as sampling equipment, frequency, and method. The Field Procedures Manual component of the Technical Plan (Standard Operating Procedures [SOPs]) for the Comprehensive Air Quality and Meteorological Monitoring Program (EBASCO 1992) discusses specific sample handling procedures. All procedures implemented in the development of this database are in agreement

with Program Manager for Rocky Mountain Arsenal (PMRMA)/U.S. Army Toxic and Hazardous Materials Agency (USATHAMA) requirements for sample collection, sample preservation, sample shipment, sample analysis, and chain-of-custody protocol.

3.2.1 Location of Air Quality Monitoring Stations

Air samples were collected from permanent and mobile air quality stations at RMA. Figure 3.2-2 shows the locations of the permanent stations on the perimeter of RMA, and near Basins A and F, the South Plants area, the North Plants complex, and the rail classification yard. Portable air quality stations were also used and their locations depended on high-event conditions.

Locations of air quality stations were based on the following criteria:

- Proximity to a suspected contaminant source or RMA boundaries
- Predominant wind speed and direction
- Topographical features and obstructions
- Continuity with previous monitoring programs to maintain integrity of data collected in the past

These criteria are discussed below.

3.2.1.1 Proximity to Sources or Boundaries

All air quality stations were located either near a contaminant source or along the RMA boundary. Samplers that were located near suspected contaminant sources were positioned to collect airborne contamination originating from the source areas; those located on the perimeter of RMA sampled airborne contaminants that were crossing RMA boundaries. Depending upon wind direction during sampling, contaminants migrating on or off post were measured.

3.2.1.2 Wind Speed/Direction

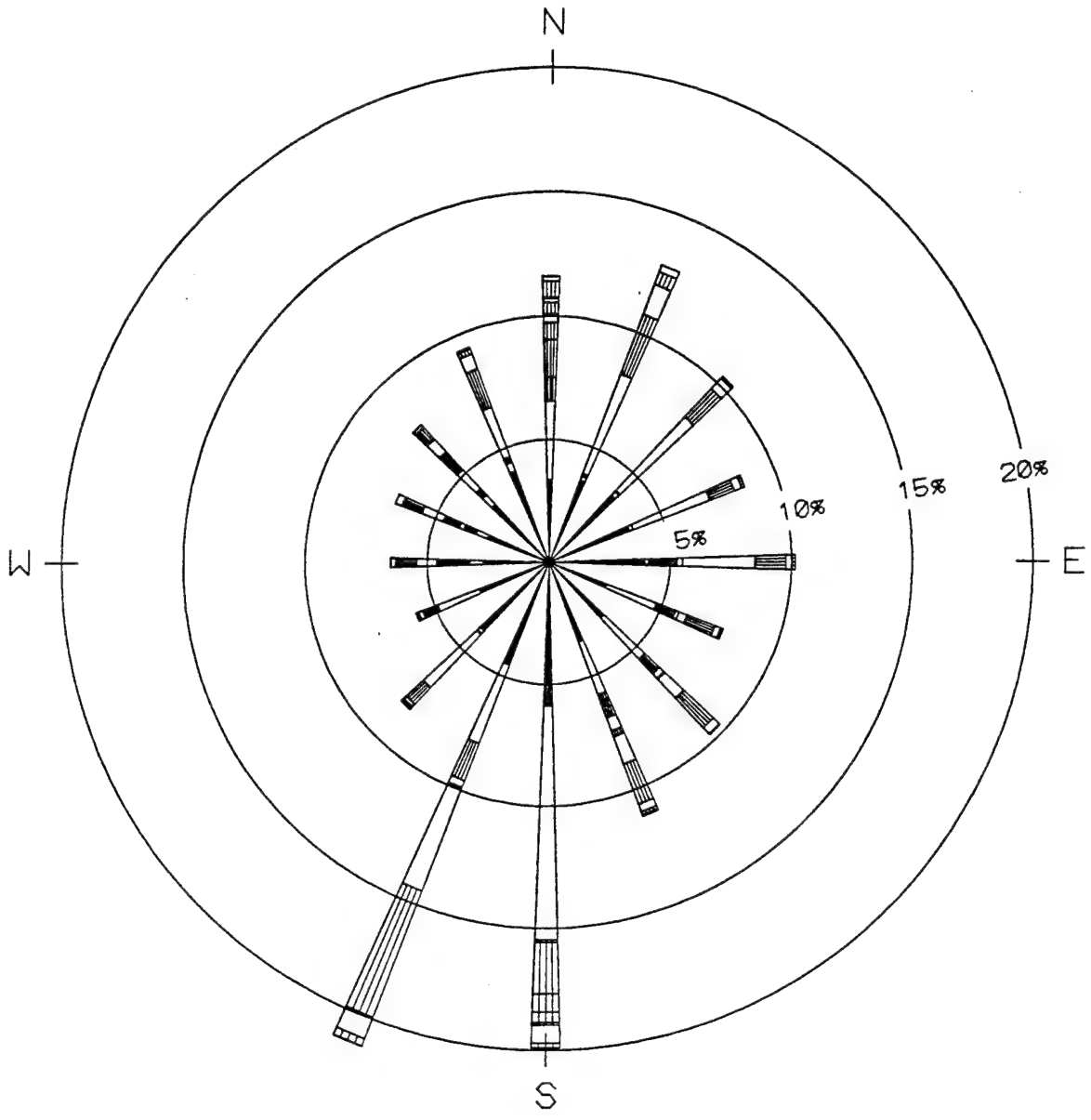
Predominant wind speeds and directions were considered in choosing the locations of air quality stations (RLSA 1990b). Figure 3.2-1 shows wind speed and direction frequencies in the vicinity of RMA for 1993. The prevailing winds are from the south and south-southwest, representing night-time drainage. The next most frequent wind directions are from the north and north-northeast, representative of typical daytime upslope heating. While the wind rose represents typical wind conditions, variable meteorological conditions can occur on any given day along the Front Range (and were observed during the FY93 program).

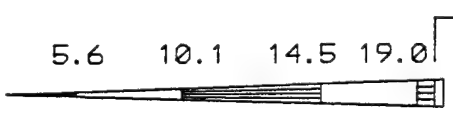
3.2.1.3 Topographical Features and Obstructions

Air quality sampling locations were selected to be consistent with siting criteria provided in Ambient Monitoring Guidelines for Prevention of Significant Deterioration (PSD) (EPA 1987).

The following general guidelines were followed in selecting the monitoring sites:

- Stations were at least 20 meters (m) from trees.
- Stations were located away from buildings or other obstacles so that the distance between the obstacle and sampler was equal to at least twice the height that the obstacle protrudes above the sampler. Exceptions occasionally involved high-event sampling, in which case the siting was optimized to avoid sampler inlet obstructions.
- At stations with multiple samplers, the samplers were spaced at least 2 meters apart.
- When possible, the stations were located at least 25 meters from roadways.
- The sample inlets were 2 meters above ground level.
- To verify sampling precision, collocated TSP and PM-10 samplers were located at station AQ5; station FC1 collected collocated samples for VOCs; and station FC2 collected collocated samples for OCPs and SVOCs.





WIND SPEED CLASS BOUNDARIES
(MILES/HOUR)

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 3.2–1
Rocky Mountain Arsenal
Wind Rose for FY93

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

3.2.1.4 Permanent Air Quality Monitoring Network

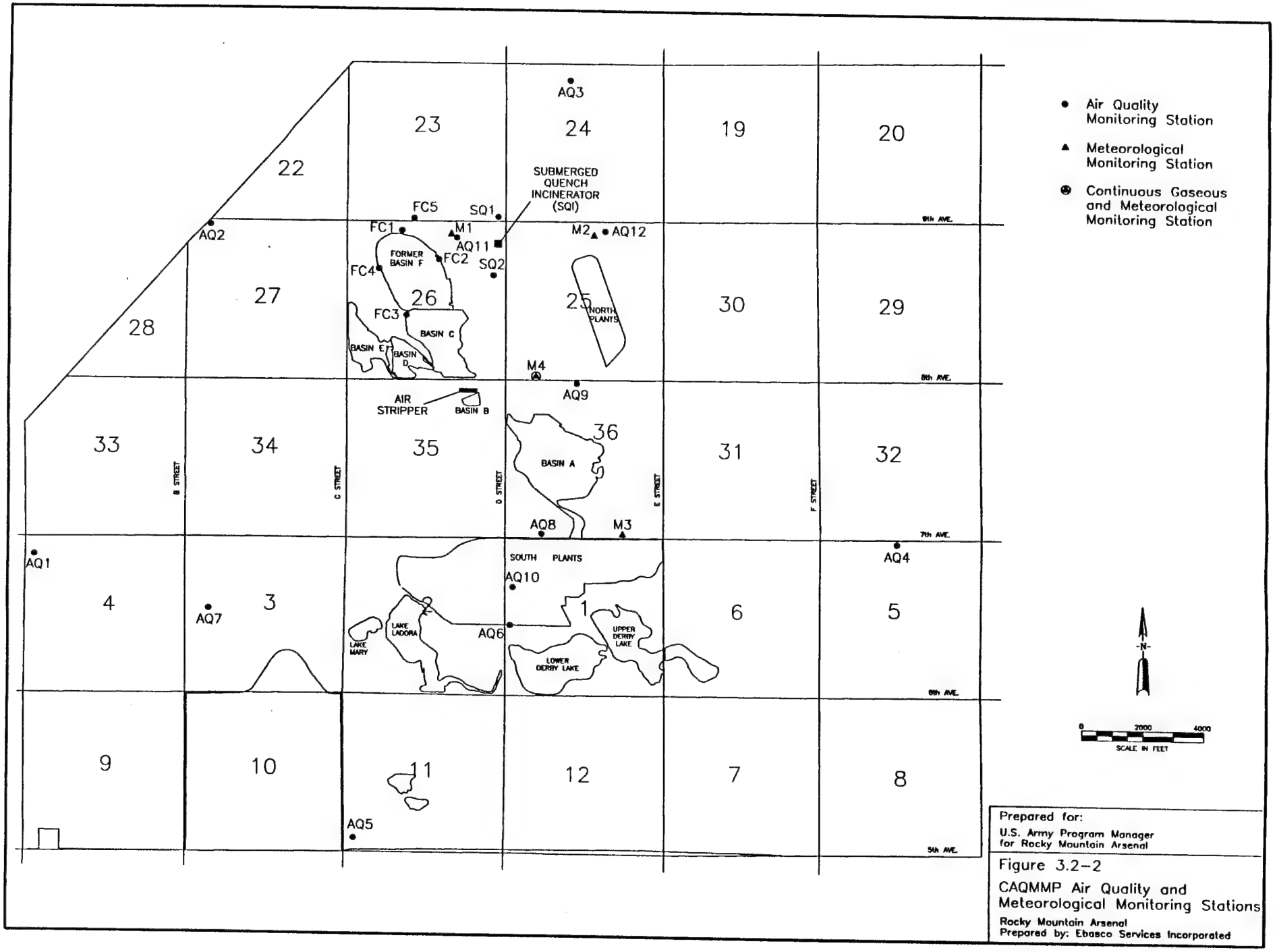
The CMP/CAQMMP has operated samples at 11 permanent air quality stations and one mobile air quality station (AQ10) since its inception in 1988 (Figure 3.2-2). In 1991, five IRA-F air monitoring sites (a special monitoring program designed as a follow-up to the Basin F remedial activities) were combined with the CMP program. The intent of the expanded monitoring was to continue sampling for atmospheric emissions of concern and to characterize the impacts of Basin F remedial activities. Sampling at the IRA-F sites has focused on VOCs and OCPs near Basin F and the storage pond for Basin F liquids. Additionally, two permanent sites at the SQI facility (SQ1 and SQ2) were added to the CMP air project. These sites were designed for measurement of TSP, PM-10, OCPs, VOCs, metals, arsenic, and mercury.

In 1989, a permanent criteria pollutant air quality monitoring station was installed near the southwest boundary of Section 25. This site was instrumented for continuous measurement of carbon dioxide, nitrogen dioxide, ozone, and sulfur dioxide, and meteorologic data. The site was centrally located and was selected to be representative of general air quality conditions at RMA.

The following paragraphs describe the existing CAQMMP sampling network. For the most part, these stations have been in operation since 1988, except as noted elsewhere in this report.

Air Quality Station 1 (AQ1):

This station was located on the western boundary of RMA, approximately 300 yards south of the west gate in Section 4. The purpose of this site was to determine impacts from the Denver metropolitan area on RMA under westerly wind conditions, as well as from RMA on adjacent areas under easterly flows. TSP, PM-10, and asbestos were routinely monitored at AQ1, and during high-event conditions, VOCs, SVOCs, metals, arsenic, and mercury were also monitored. During FY93, VOCs and SVOCs were also measured quarterly.



Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal

Figure 3.2-2

CAQMMP Air Quality and Meteorological Monitoring Stations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Air Quality Station 2 (AQ2):

AQ2 was located on the northwestern boundary of RMA at the west end of 9th Avenue in Section 27. This site monitored metropolitan area baseline effects with northwest flow, and suspected RMA contaminant source impacts with southeast flow. The station was approximately 100 yards south of 9th Avenue. TSP, PM-10, VOCs, OCPs, metals, arsenic, and mercury were monitored at AQ2 during routine and high-event conditions.

Air Quality Station 3 (AQ3):

AQ3 was located on the northern boundary of RMA in Section 24. This site monitored area baseline effects with northerly flow, and possible RMA influences with southerly flows. It was 100 yards west of North Boundary System well 47. TSP, PM-10, VOCs, OCPs, SVOCs, metals, arsenic, and mercury were monitored at AQ3 during routine and high-event conditions.

Air Quality Station 4 (AQ4):

This station was approximately one-half mile from RMA's east boundary fence and about 50 yards south of 7th Avenue in Section 5. The site provided data on area baseline impacts with easterly flows, and possible RMA influences with westerly flows. TSP and PM-10 were routinely monitored at this site. During FY93, VOCs, SVOCs, arsenic, metals, and mercury were also monitored at AQ4 on a seasonal basis.

Air Quality Station 5 (AQ5):

AQ5 was located approximately 200 yards from RMA's southern boundary fence, directly south of Lake Ladora in Section 11. This site provided Denver metropolitan area baseline impacts with southerly flows, and possible RMA influences with northerly flows. AQ5 was designated as the collocated station for the precision measurement of TSP, PM-10, and metals. TSP, PM-10, VOCs, OCPs, metals, and arsenic were monitored at AQ5 on a routine basis. VOCs, SVOCs, metals, arsenic, and mercury were also monitored at AQ5 under high-event conditions in FY93; SVOCs were also monitored seasonally.

Air Quality Station 6 (AQ6):

AQ6 was located 50 yards just north of the northeastern corner of Lower Derby Lake in Section 1. This site monitored suspected RMA contaminant source impacts, in particular the South Plants area, under northerly flow. TSP, PM-10, VOCs, OCPs, SVOCs, metals, arsenic, mercury, and asbestos were routinely monitored at AQ6.

Air Quality Station 7 (AQ7):

AQ7 was located in Section 3. This site provided baseline data along the south border of RMA and, in particular, impacts from the Stapleton International Airport runway. TSP was monitored at this site.

Air Quality Station 8 (AQ8):

This station was located approximately 400 yards east of the fire station and 50 yards north of 7th Avenue in Section 36. This station monitored suspected contaminant source impacts from Basin A with northerly flow, and suspected impacts from the South Plants with southerly flows. TSP, PM-10, OCPs, SVOCs, metals, arsenic, mercury, and asbestos were monitored at AQ8.

Air Quality Station 9 (AQ9):

AQ9 was located approximately 25 yards south of 8th Avenue in the center of Section 36. This station measured direct impacts from Basin A with southerly flow, and direct impacts from the North Plants under northerly flow. TSP, PM-10, and OCPs were monitored at AQ9.

Air Quality Station 10 (AQ10):

AQ10 was a mobile monitoring station strategically located to measure impacts of significant ongoing remedial activities. In FY93, AQ10 was located approximately 100 yards east of D Street and 600 yards south of 7th Avenue in the South Plants area in Section 1. TSP and PM-10 were monitored at AQ10 on a routine basis. This site was subject to relocation as potential impacts were identified from RMA ongoing remedial activities.

Air Quality Station 11 (AQ11):

AQ11 was located north of Basin F approximately 200 yards south of 9th Avenue and 0.3 miles west of D Street in Section 26. This site monitored direct impacts from Basin F with southerly winds. TSP was monitored at AQ11.

Air Quality Station 12 (AQ12):

AQ12 was located north of the North Plants, approximately 200 yards south of 9th Avenue and 0.6 miles east of D Street in Section 25. This site measured suspected contaminant source impacts from the North Plants with southerly flow, and also suspected impacts from Basin F with westerly flow. TSP and asbestos were monitored at AQ12.

IRA-F Air Quality Sites (FC1 – FC5):

These sites surrounded the remediated Basin F areas. Sampling activities focused on impacts from Basin F and from the storage pond for Basin F liquids. TSP, PM-10, VOCs, SVOCs, OCPs, metals, arsenic, and mercury were sampled at these sites.

Submerged Quench Incinerator Sites (SQ1 and SQ2):

Sampling activities at the SQI sites were initially designed to provide background or baseline air quality information in the vicinity of the SQI. SQ1 was located to the north of the incinerator in Section 23, and SQ2 was located to the south of the incinerator in Section 26. TSP, PM-10, VOCs, OCPs, metals, arsenic, and mercury were monitored at these sites. During FY93, the SQI sites measured potential impacts from the SQI operations that commenced on April 16, 1993. More details of these activities are provided in Section 4.10.

3.2.1.5 Real-Time Cap and Vent Monitoring

Real-time monitoring of the Basin F waste pile vents and cap, the restored Basin F floor, around Pond A, and on the three Basin F liquid storage tanks was conducted to characterize emissions of these potential sources to aid in assessing their possible impact on ambient air quality. This involved taking real-time readings of total organics using both an OVA and an OVM (see Section

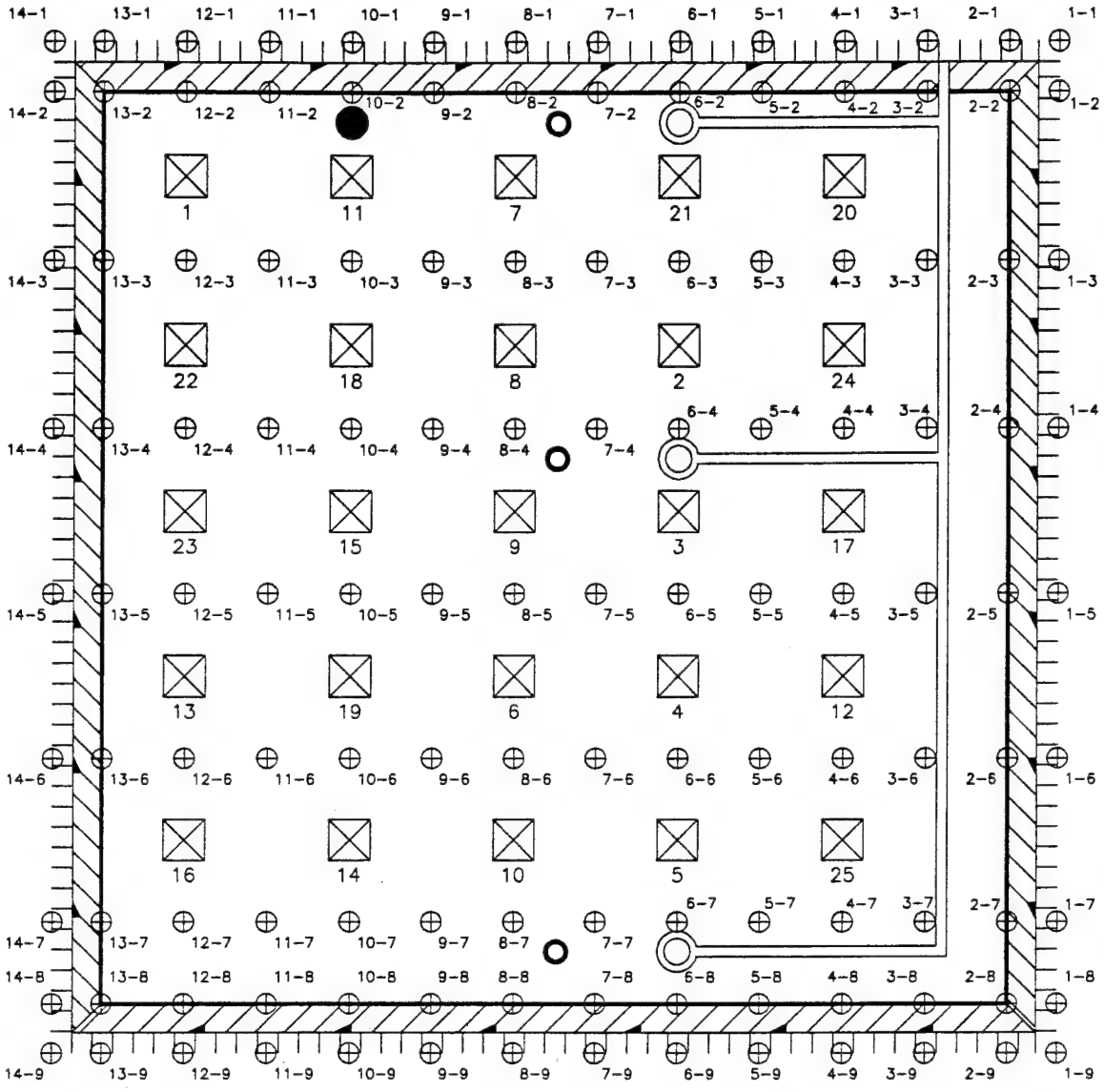
4.8), as well as monitoring hydrogen sulfide and ammonia with appropriate monitors. In addition, VOC sampling was conducted at the vents having highest real-time readings.

During construction of the Basin F waste pile, a total of 25 passive off-gas release vents were installed through the liner to relieve potential air pressure gradients from recurring atmospheric pressure changes and from internal vaporization of contaminants. The vents were spaced in a grid pattern across the waste pile (Figure 3.2-3), and numbered in a random numbering scheme. The height of each vent varied with the depth of the waste pile cap and ranged from 1 to 3 feet above ground. Vent pipes were 6 inches in diameter and terminated in a down-curved opening.

Real-time monitoring of the waste pile vents consisted of readings taken about 1 inch below the vent opening on the downwind side during periods when winds were light (less than 10 mph) and atmospheric pressure was dropping. Readings were taken with an OVA and an OVM for total organics; hydrogen sulfide and ammonia concentrations were also monitored by specific real-time instruments. Each sample reading was taken over approximately a 30-second interval.

Real-time readings of the waste pile cap surface were also taken. The instruments were each fitted with an extension tube ending in a small funnel. The technician traversed the waste pile cap in a predetermined pattern and collected representative readings at a total of 126 marked locations regularly spaced across the waste pile (Figure 3.2-3). An air sample was drawn from approximately 1 inch above ground at each location, and real-time readings were recorded on field data sheets.

Similar readings were taken from the restored Basin F floor, which has been covered with a clay and topsoil cap. The Basin F floor readings were taken at 115 regularly spaced locations marked by sandbags (Figure 3.2-4). Weather conditions and the physical appearance of the floor during each sampling episode were recorded prior to commencement of sampling.



LEGEND

5 Vent with Existing Vent Number

Sand Bags

Baseplate Standpipe

Detection Sump and Baseplate Standpipe

Leachate Collection Sump and Baseplate Standpipe

Transfer Pipe

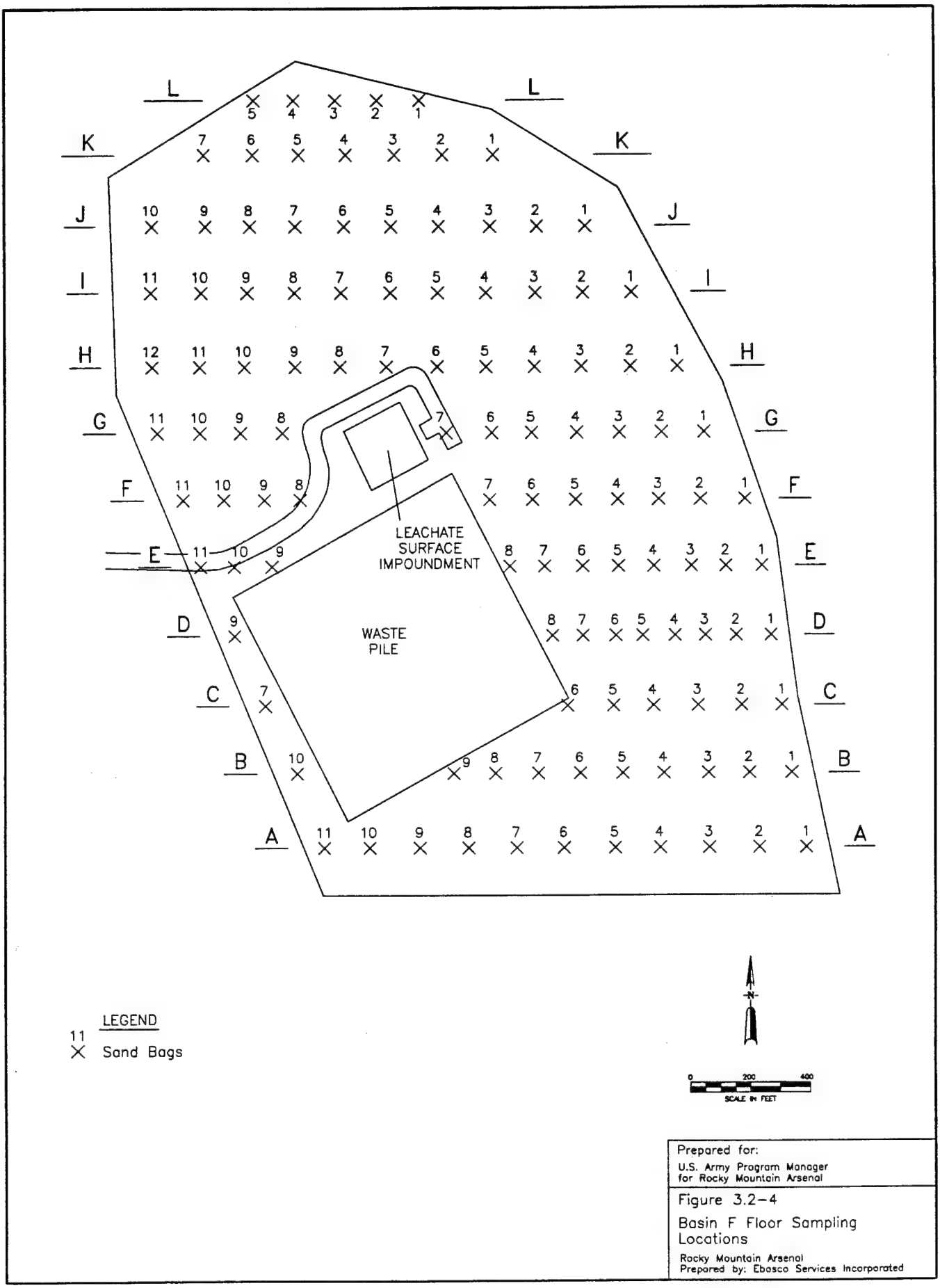
NOT TO SCALE

Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 3.2-3

Waste Pile Vent Locations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 3.2-4

Basin F Floor Sampling Locations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Pond A is a double-lined liquid storage pond located just north of Basin F. The pond was covered with a high-density polyethylene cover and four special vents, one along each side of the pond. The vents were equipped with trip valves that open to allow emission of gases and close to prevent entrapment of air beneath the pond cover. As a result, the pond gases have been emitted in short pulses. Sampling the pond vents required a sample duration that spans several pulses of the trip valve. Pond A vents were sampled with the real-time monitors quarterly.

The three Basin F liquid storage tanks were covered by metal roofs with passive vents atop each tank. The sampling crew performed real-time sampling of the vapors through a Tygon tubing extension for the analyzer probes.

3.2.2 Documentation of Monitoring Locations

The reference number for each air quality station was affixed to a metal tag on each station. Under the previous monitoring programs, all stations were numbered and their map coordinates and ground surface elevations determined by a registered surveyor. For the portable sample locations, several locations were surveyed in the vicinity of major contaminant sources to account for expected emission routes from the sources. This documentation has been maintained as appropriate for the ongoing monitoring program (Table 3.2-1). If, during the FY93 investigation period, an unsurveyed site was used as a monitoring location, the location was staked and surveyed to document the location.

3.2.3 Air Quality Monitoring Strategies

There were several investigating elements conducted during the FY93 CAQMMP. The first element was the collection of baseline data for TSP, PM-10, VOCs, OCPs, metals, arsenic, and mercury for routine sampling periods. Table 3.2-2 lists the parameters and schedule for the program.

Table 3.2-1 Permanent CAQMMP and High-Event Mobile Site Locations for FY93

SITE IDEN-TIFI-CATION	ELEVATION (feet)	NAD 1983 STATE PLANAR (feet) NORTHING	NAD 1983 STATE PLANAR (feet) EASTING	UTM (meters) NORTHING	UTM (meters) EASTING
MET 1	5192.43	190632.43	2181737.97	4411447.77	512602.06
MET 2	5193.76	190523.61	2186253.84	4411406.83	513977.77
MET 3	5263.19	180733.49	2187493.00	4408421.80	514338.40
MET 4	5278.70	185997.34	2184581.95	4410030.65	513460.58
AQSITE	5278.54	186089.28	2184630.75	4410058.58	513475.60
AQ1	5172.90	179894.09	2168044.46	4408199.59	508411.43
AQ2	5131.03	190950.25	2173808.13	4411558.25	510186.54
AQ3	5141.14	195895.65	2185671.67	4413044.59	513089.64
AQ4	5299.22	180536.12	2196630.92	4408345.96	517122.24
AQ5	5266.50	170517.42	2178593.75	4405324.56	511609.43
AQ6	5259.90	177674.96	2183761.74	4407496.40	513196.34
AQ7	5196.10	178246.45	2174165.98	4407687.05	510273.70
AQ8	5263.93	180741.57	2184793.38	4408429.20	513515.94
AQ9	5271.20	185767.70	2185937.88	4409958.35	513873.31
AQ10	5265.00	178950.00	2183850.00	4407884.73	513225.43
AQ11	5192.00	190596.94	2181735.99	4411436.96	512601.39
AQ12	5186.02	190620.16	2186724.88	4411435.44	514121.45
FC1	5191.10	190812.80	2180129.05	4411505.49	512112.16
FC2	5201.80	189877.06	2181324.36	4411218.40	512474.60
FC3	5209.80	187997.29	2180259.12	4410647.40	512146.90
FC4	5193.40	189688.41	2179373.28	4411164.20	511879.90
FC5	5187.90	191232.76	2180501.15	4411632.90	512226.20
SQ1*	5186.19	191300	2183300	4411648	513079
SQ2	5217.64	189365.39	2183150.26	4411059.29	513030.17

* MAP READ

NAD = North American Datum
UTM = Universal Transverse Mercator

Table 3.2-1 Permanent CAQMMP and High-Event Mobile Site Locations for FY93

SITE IDEN-TIFI-CATION	ELEVATION (feet)	NAD 1983 STATE PLANAR (feet) NORTHING	NAD 1983 STATE PLANAR (feet) EASTING
M1E	5210	190250	2184800
M136E	5242	182600	2189000
M236W	5240	183650	2183450
M301N	5259	180800	2187625
M401E	5257	179500	2189000
M501S	5260	178500	2187750
M201W	5267	179500	2185625
M101E	5256	180800	2188990
M125W	5198	190400	2183600
M436W	5245	182000	2183725
M336E	5238	182000	2186500
M226E	5230	188500	2182050
M601N	5265	179250	2185750
M701N	5265	179150	2185650
M122SW	5130	191375	2174250
M127NW	5135	190875	2174625
M227NW	5135	190625	2174250
M102E	5267	179500	2182375
M801N	5280	179500	2187375
M225W	5198	190400	2183600
M326E	5235	189250	2180875
M426S	5235	188750	2180750
M526SE	5190	189000	2181125
M104NE	5210	176375	2178933
M102W	5210	175750	2173625
M134E	5210	183125	2178125
M135N	5210	185500	2182500

NOTES: All coordinates are map read.

NAD = North American Datum
UTM = Universal Transverse Mercator

Table 3.2-2 CAQMMP Baseline Air Monitoring Schedule FY93

Parameter	Frequency	Location	Regular Samples	Blanks	Duplicates	Total Samples
TSP	6th Day	AQ1, AQ2, AQ3, AQ4, AQ5, 5Dup, AQ6, AQ7, AQ8, AQ9, AQ10, AQ11, AQ12, SQ1, SQ2, Field Blank	854	61	61	976
	12th Day	FC1, FC2, FC5	93	0	0	93
	Monthly	FC3, FC4	24	0	0	24
PM-10	6th Day	AQ1, AQ2, AQ3, AQ4, AQ5, 5Dup, AQ6, AQ8, AQ9, AQ10, SQ1, SQ2	671	0	61	732
	12th Day	FC1	31	0	0	31
Asbestos	Monthly	AQ1, AQ6, 6Dup, AQ8, AQ12, Field Blank, Trip Blank	48	24	12	84
OCPs	6th Day	AQ2, AQ3, AQ5, AQ6, AQ8, AQ9, FC1, FC2, 2Dup, FC5, SQ1, SQ2, Field Blank	671	61	61	793
	Monthly	FC3, FC4	24	0	0	24
SVOCs	Monthly	FC2, 2Dup, Field Blank (Split Off OCP Samples)	12	12	12	36
	Seasonal	AQ1, AQ2, AQ3, AQ4, AQ5, 5Dup, AQ6, AQ8 Field Blank	28	4	4	36

Table 3.2-2 CAQMMP Baseline Air Monitoring Schedule FY93

Parameter	Frequency	Location	Regular Samples	Blanks	Duplicates	Total Samples
SVOCs Field Spikes	Quarterly	AQ5, 5Dup, 5Ambient, Field Blank, Trip Blank	8	8	4	20
Metals	6th Day	AQ2, AQ3, AQ5, 5Dup, AQ6, AQ8, SQ1, SQ2, Field Blank	427	61	61	549
	12th Day	FC1, FC2 FC5	93	0	0	93
	Monthly	FC3, FC4	24	0	0	24
Arsenic	6th Day	AQ2, AQ3, AQ5, 5Dup, AQ6, AQ8, SQ1, SQ2, Field Blank	427	61	61	549
	12th Day	FC1, FC2, FC5	93	0	0	93
	Monthly	FC3, FC4	24	0	0	24
Mercury	6th Day	AQ2, AQ3, AQ5, 5Dup, AQ6, AQ8, SQ1, SQ2, Field Blank	427	61	61	549
	12th Day	FC1, FC2, FC5	93	0	0	93
	Monthly	FC3, FC4	24	0	0	24
VOCs tenax-tenax/carbon	6th Day	AQ2, AQ3, AQ5, AQ6, FC1, 1Dup, FC2, FC5, SQ1, SQ2, Field Blank, Trip Blank	549	122	61	732
	Monthly	FC3, FC4	24	0	0	24
	Seasonal	AQ1, AQ1Dup, AQ4, Field Blank, Trip Blank	8	8	4	20

Table 3.2-2 CAQMMP Baseline Air Monitoring Schedule FY93

Parameter	Frequency	Location	Regular Samples	Blanks	Duplicates	Total Samples
VOCs	Quarterly	4 High OVA/OVM Vents on Waste Pile, 1 High Vent at Pond A, 3 Tank Vents, Duplicate, Trip Blank, Field Blank	32	8	4	44
VOCs tenax-tenax-	Weekly	Air Stripper Port B	52	0	0	52
	Monthly	Air Stripepr Port A, Port B, Port BDup, Port C, Port D, Field Blank	36	12	12	60
SVOCs -(XAD)	Weekly	Air Stripper Port B	52	0	0	52
	Monthly	Air Stripper Port A, Port B, Port BDup, Port C, Port D, Field Blank	36	12	12	60
CO, NO_x, O_3,SO_2	Continuous Hourly Averages	Met 4	8760/parameter	0	0	35040

CO - Carbon Monoxide
DUP - Duplicate
NO_x - Nitrogen Oxides
O_3 - Ozone
SO_2 - Sulfur Dioxide
SVOCs - Semivolatile Organic Compounds
VOCs - Volatile Organic Compounds
XAD - Semivolatile organic Compound Sample Cartridge

The second element was real-time monitoring using an FID-type OVA, a PID-type OVM, and hydrogen sulfide and ammonia real-time monitors at the Basin F waste pile vents and cap, Pond A, and the three holding tanks. Similar real-time monitoring was conducted at the four Basin A Neck facility air stripper locations. Table 3.2-3 provides the parameters monitored, number of samples, sampling schedule, and location.

The third element was high-event and contingency monitoring. High-event monitoring was conducted in the vicinity of suspected contaminant source areas using both permanent and mobile monitors (Table 3.2-4). Due to the low background levels that have been encountered in these areas under generalized weather conditions, sampling for compounds was directed toward high-event days or worst-case meteorological situations. In addition, contingency monitoring was conducted in the vicinity of remedial activities in order to assess potential worst-case conditions where ground disturbances occurred. Various strategies have been developed to optimize the high-event collection program.

The fourth element was the continuous monitoring of gaseous pollutants including carbon monoxide, sulfur dioxide, ozone, and nitrogen dioxide. This program has been required to establish a baseline of gaseous pollutants relating to future RMA activities and to assess the status of nonattainment pollutants or those of special concern in the Denver metropolitan area.

A final element was the CAQMMP support of special RMA activities such as the SQI operations and the SVE activities. Support for these programs are discussed below.

3.2.3.1 Baseline Sampling

Samples were collected and analyzed for TSP, PM-10, VOCs, OCPs, metals, arsenic, and mercury every sixth day for the entire year following a standardized annual schedule that is generally applied on a national basis. As shown in Table 3.2-2, these parameters were also collected on

Table 3.2-3 CAQMMP Real-Time Baseline Air Monitoring Schedule FY93

Parameter	Frequency	Location	Regular Samples	Blanks	Duplicates	Total Samples
OVA/OVM, H_2S, NH_3	Seasonal	Waste Pile Vents (25)	100	0	0	100
	Seasonal	Pond A Vents (4)	16	0	0	16
	Seasonal	Holding Tanks (2)	12	0	0	12
	Seasonal	Basin F Cap (115 sites)	460	0	0	460
	Seasonal	Waste Pile Cap (126 sites)	504	0	0	504
OVA/OVM	Weekly	Air Stripper Port A, B, C, D	208	0	0	208

OVA - Organic Vapor Analyzer
OVM - Organic Vapor Meter
H_2S - Hydrogen Sulfide
NH_3 - Ammonia

Table 3.2-4 CAQMMP High-Event Monitoring Requirements FY93

Parameter	Frequency	Location	Regular Samples	Blanks	Duplicates	Total Samples
VOCs	Seasonal (4) & 8 additional events	6 Sample Sites, Duplicate, Field Blank, Trip Blank	72	24	12	108
SVOCs	Seasonal (4) & 8 additional events	6 Sample Sites, Duplicate, Field Blank	72	12	12	96
Metals	Seasonal (4) & 8 additional events	6 Sample Sites, Duplicate, Field Blank	72	12	12	96
Arsenic	Seasonal (4) & 8 additional events	6 Sample Sites, Duplicate, Field Blank	72	12	12	96
Mercury	Seasonal (4) & 8 additional events	6 Sample Sites, Duplicate, Field Blank	72	12	12	96

SVOCs - Semivolatile Organic Compounds
VOCs - Volatile Organic Compounds

12-day, monthly, and seasonal schedules at several sites. Detailed monitoring methods are provided in Section 3.3 as well as in the Field Procedures Manual. Section 3.7 describes the laboratory analytical procedures.

3.2.3.2 High-Event Sampling

Because of seasonal and weather-related characteristics, monitoring for VOCs, SVOCs, metals, arsenic, and mercury was conducted on high-event days as shown in Table 3.2-4. The criteria for identifying high-event days are specific to the contaminant of concern. In general, VOCs were sampled during periods with warm temperatures, low humidity, and low wind speeds (however, seasonal high-event sampling encompassing all conditions was also conducted). The sampling was generally conducted for a full 24-hour period in order to identify periods when volatilization is at a maximum level (during the hottest time of the day), as well as periods when dispersion conditions are least favorable (early evening through early morning when winds are light and stable atmospheric conditions exist). SVOCs may reach their peak levels under identical conditions, but may also reach high levels under warm and windy conditions; consequently, they were sampled under two high-event scenarios. Metals were sampled during high winds and dry conditions.

On-post CAQMMP personnel initiated sampling based on atmospheric and source conditions. Using meteorological reports and alert criteria and information provided in Table 3.2-5, field personnel determined whether or not sampling should take place and for which potential contaminants based upon the on-post meteorological network data. When certain conditions were met for VOCs, SVOCs, or metals, on-post personnel conferred with the Ebasco Services Incorporated (EBASCO) Air Element Technical Manager to verify atmospheric conditions and to select sample locations. If atmospheric conditions were anticipated to remain constant through an appropriate monitoring period, mobilization of monitoring equipment commenced. Generally, the stations were readied for sampling in less than 2 hours. Once the samplers were in place, the project team re-evaluated atmospheric conditions involving maximum use of telemetered

Table 3.2-5 Target Meteorological Conditions for High-Event Air Quality Monitoring

Atmospheric Parameter	High-Event Conditions		
	VOC/SVOC/OCP	Alternate SVOC/OCP	Metals
Wind Speed	< 5 mph	> 10 mph	> 10 mph
Temperature	> 75°F	> 75°F	N/A
Relative Humidity	< 50%	N/A	N/A
Precipitation	None	None	None
Soil Moisture	Dry	Dry	Dry
Snow Cover	None	None	None

mph - miles per hour
OCP - Organochlorine Pesticides
SVOC - Semivolatile Organic Compounds
VOC - Volatile Organic Compounds
°F - Degrees Fahrenheit
N/A - Not Applicable
% - Percent

meteorological data and either started sampling or remained poised to start once conditions were favorable. Stability criteria relating to high-event monitoring are shown in Table 3.2-6.

3.2.3.3 Contingency Sampling

Contingency sampling was conducted in the vicinity of special remediation activities or identified potential RMA sources upon direction and/or coordination with PMRMA. Contingency events during FY93 included an emergency response at manhole covers near Building 511, an excavation near the water treatment plant at Section 35, soil sifting in Basin A, and Pond A liner cleaning, as well as more elaborate special monitoring conducted for the SQI and SVE activities discussed below. Samples taken generally followed high-event guidelines (although meteorological conditions did not necessarily determine the criteria) and were deducted from the high-event sampling schedule, unless additional sampling events were authorized by PMRMA. Contingency sampling occurred with limited notice.

SQI Air Quality Support Program

One of the major remedial activities during the FY93 period at RMA was the testing and operational implementation of the SQI facility. The CAQMMP provided intensive air monitoring support to this activity. The program consisted of the special use of four existing sample locations from the ongoing CAQMMP network, located upwind and downwind from the SQI. The full impact of potential SQI stack emissions under various air dispersion patterns is discussed further in Section 4.10 which provides a summary of data collected and an assessment of results.

Ambient monitoring of the SQI facility was conducted every third day (twice the frequency of the routine CAQMMP sampling program), and every day during a special test period on June 10, 11, and 12, 1993. In addition, the full CAQMMP network was used for sampling every sixth day. Finally, special high-event monitoring was also applied for SQI assessment. Other features of the program included fast laboratory turnaround and prompt data reporting to PMRMA and the SQI staff.

Table 3.2-6 Initial Estimate Criteria and Wind Speed Adjustments for Determining Pasquill Stabilities from Sigma Theta

Initial Estimate of Pasquill Stability Category	Sigma Theta (σ_A) in Degrees
A	$22.5 \leq \sigma_A$
B	$17.5 \leq \sigma_A < 22.5$
C	$12.5 \leq \sigma_A < 17.5$
D	$7.5 \leq \sigma_A < 12.5$
E	$3.8 \leq \sigma_A < 7.5$
F	$\sigma_A < 3.8$

	Initial Estimated Category	10m Scalar Wind Speed (US) in Meters per Second	Final Estimate of Stability Category
Daytime	A	US < 3	A
		3 ≤ US < 4	B
		4 ≤ US < 6	C
		6 ≤ US	D
	B	US < 4	B
		4 ≤ US < 6	C
		6 ≤ US	D
	C	US < 6	C
		6 ≤ US	D
	D, E, or F	ANY	D
Nighttime	A	US < 2.9	F
		2.9 ≤ US < 3.6	E
		3.6 ≤ US	D
	B	US < 2.4	F
		2.4 ≤ US < 3.0	E
		3.0 ≤ US	D
	C	US < 2.4	E
		2.4 ≤ US	D
	D	ANY	D
	E	US < 5.0	E
		5.0 ≤ US	D
	F	US < 3.0	F
		3.0 ≤ US < 5.0	E
		5.0 ≤ US	D

Parameters monitored and evaluated included the full list of RMA metals, VOC and OCP target compounds, TSP, and PM-10; EPA criteria gaseous compounds (SO_2, CO_2, NO_2 and O_3); and meteorological factors (wind speed, wind direction, temperature, and atmospheric stability). Results were compared with long-term data at individual monitoring stations, pre-SQI monitoring data complied under the CAQMMP during FY91 and FY92, and previous peak concentrations at RMA during Basin F remediation activities. These results are provided in further detail in Section 4.10.

The SVE Sampling Program

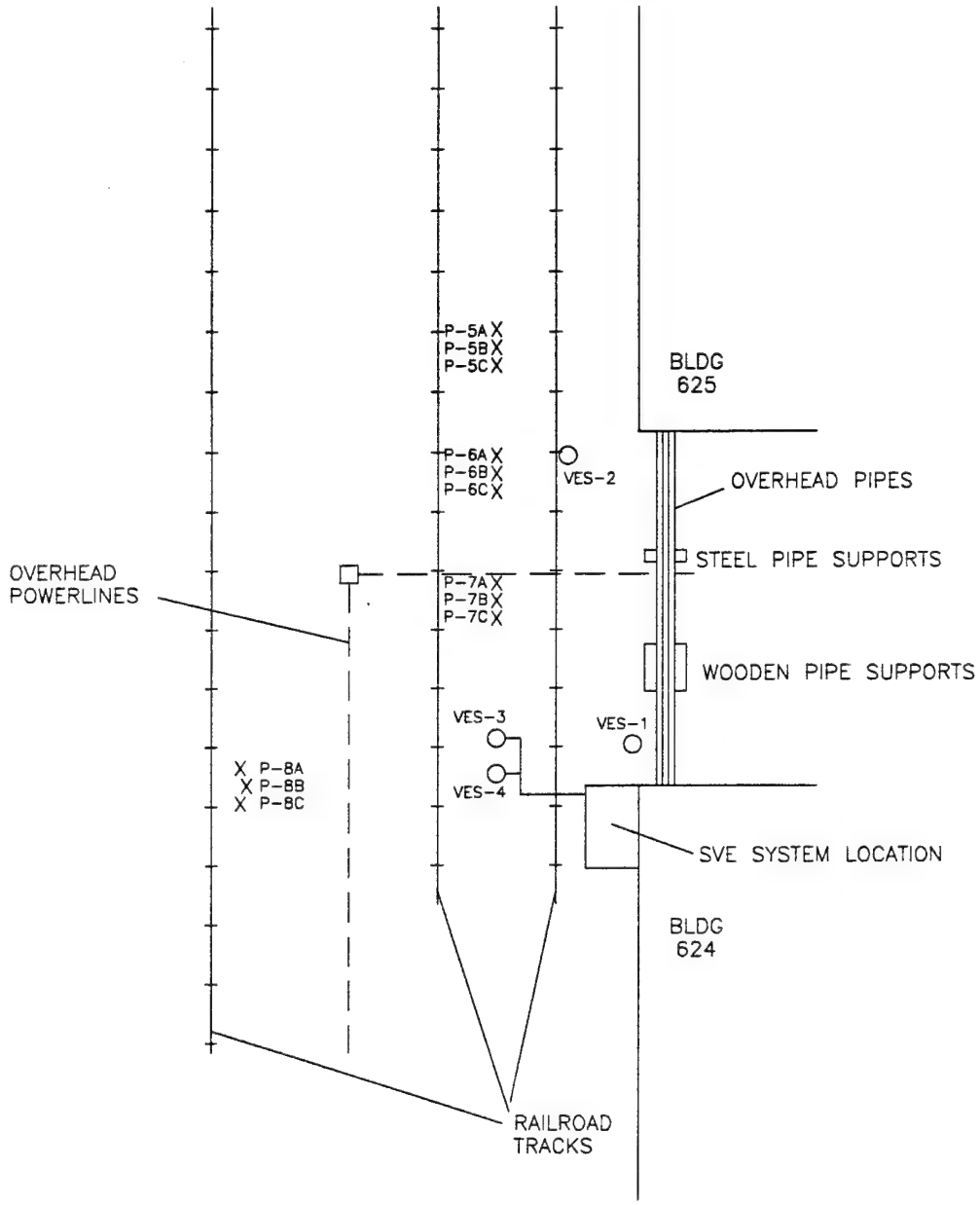
Operational testing and air monitoring of the SVE system at the area of the RMA Motor Pool (on the west side of Section 4) was performed from September 29, 1993 to October 1, 1993. The objective of this special program was to furnish additional data to PMRMA for assessing the effectiveness of the remediation conducted under the Motor Pool Area Interim Response Action Soil Vapor Extraction Pilot Study in 1991.

The SVE system was first inspected and its operability verified. Air samples were collected at the 12 soil gas monitoring wells in the area and analyzed with an on-site gas chromatograph (GC). The SVE system was operated for 48 hours and air samples were collected at the vapor extraction well sites with passivated canisters every 16 hours (Figure 3.2-5). After successful completion of the 48-hour test run, the 12 soil gas monitoring wells were again sampled and analyzed with the on-site GC. The details and results of this special sampling program are presented in Section 4.11.

3.3 AIR QUALITY MONITORING METHODS

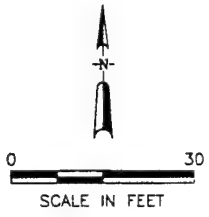
The parameters monitored were as follows:

- TSP
- PM-10
- Carbon monoxide
- Nitrogen dioxide



LEGEND

VES-1 ○	Soil Vapor Extraction Well
P-8C X	Soil Gas Monitoring Well
SVE	Soil Vapor Extraction
BLDG	Building



Prepared for:
U.S. Army Program Manager
for Rocky Mountain Arsenal

Figure 3.2–5

Motor Pool Area Soil Vapor Extraction System Well Locations

Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

- Ozone
- Sulfur dioxide
- Hydrogen sulfide
- Asbestos
- VOCs
- SVOCs
- OCPs
- Metals
- Arsenic
- Mercury
- Ammonia

Collection or monitoring methods for TSP, PM-10, carbon monoxide, nitrogen dioxide, sulfur dioxide, ozone, and asbestos were standard reference methods used by the EPA or the National Institute of Occupational Safety and Health (NIOSH). No certification was necessary for these methods. Collection methods for VOCs, SVOCs, OCPs, metals, arsenic, and mercury were not standard reference methods and required certification by the PMRMA/USATHAMA.

The SOPs for the CAQMMP (EBASCO 1992) contained the field sampling forms and specific operation, calibration, and maintenance procedures for the TSP and PM-10 samplers; as well as for the continuous air quality analyzers for carbon monoxide, nitrogen dioxide, sulfur dioxide, and ozone.

The following sections describe, in general, the procedures followed for collecting samples and monitoring the primary pollutants.

3.3.1 Total Suspended Particulates

TSP were monitored at 19 of the air quality stations (Table 3.2-2). Samples were collected every sixth day according to the CDH Air Pollution Control Division schedule at 14 of the air quality

sites. In addition, TSP samples were taken every 12 days at 3 sites and once per month at 2 sites. For quality assurance purposes, a collocated TSP sampler was located at AQ5. This sampler was used to assess the precision of the TSP sampling at RMA. Sample collection and analytical procedures for TSP followed the EPA reference method as described in 40 CFR Part 50, Appendix B, Reference Method for the Determination of Suspended Particulate Matter in the Atmosphere (High-Volume Method). Quartz fiber filters were used to collect the TSP samples over 24-hour periods starting at midnight of a sampling day. The detection range for this method was 2 to 750 micrograms per standardized cubic meter of air (std m^3).

The high-volume (Hi-Vol) sampler used was the General Metal Works Model GMWL-2000H. Air flow was controlled by electronic mass flow controllers. An installed pressure transducer/recorder indicated the air flow to provide a permanent record of the flow rate for each sample. A 6-day timer (Model GMW-70) was built into the instrument to start and stop the sampler at the required times.

3.3.2 Respirable Particles

PM-10 concentrations were monitored every 6 days at AQ1, AQ2, AQ3, AQ4, AQ5, AQ6, AQ8, AQ9, AQ10, SQ1, and SQ2. In addition, PM-10 concentrations were monitored once every 12 days at FC1. Samples were collected on the same schedule as for TSP sampling. A collocated PM-10 sampler was located at AQ5 to assess the precision of the PM-10 network. Sampler collection and analytical procedures followed standard procedures similar to TSP monitoring; Whatman QM-A quartz filters were used to collect the PM-10 samples. A General Metal Works size-selective Accu-Vol PM-10 Sampler with a Model 1200 Inlet was used. Particles 10 μm or less in size passed through the impaction chamber inlet and were collected on the filter.

Calibration for PM-10 samplers followed the manufacturer's written protocol and EPA guidance; seasonal average temperature and pressure data were used in establishing actual (volumetric) flow control set points per the manufacturer's calibration recommendations. The PM-10 samplers and

associated manufacturer's operation manuals were both included in EPA reference and equivalency designations.

PM-10 and TSP filters were prepared in the same manner. Each filter was inspected for imperfections and numbered. Following humidity and temperature equilibration and weighing, the filters were placed in manila folders and packaged for shipping to RMA for installation. PM-10 was sampled for 24 hours starting at midnight of each sampling day. Handling and shipping were consistent with TSP sampling procedures.

3.3.3 Asbestos

Asbestos samples were collected at four air quality stations: AQ1, AQ6, AQ8, and AQ12 (see Table 3.2.2). Samples were collected monthly. Sample collection and analytical procedures followed the NIOSH Method 7400, revised March 1, 1987. The samples were collected over a 24-hour period starting at noon on the day before the declared sampling day and ending at noon of the sampling day. Asbestos samples were delivered to the RMA Engineering Design Building (Building 111) for analysis with asbestos air monitoring samples from other RMA programs. Sample volume, microscope count field area, and background airborne particles defined the usable range of the method. The minimum total fiber count in 100 microscope fields considered adequate for reliable quantification was 10 fibers.

3.3.4 Volatile Organic Compounds

VOCs were collected every 6 days at sampling stations AQ2, AQ3, AQ5, AQ6, FC1, FC2, FC5, SQ1, and SQ2. Additional sampling was performed at stations FC3 and FC4 on a monthly basis and at stations AQ1 and AQ4 on a once-per-season basis (Table 3.2-2). As part of the baseline VOC sampling program, one trip blank, one field blank, and one collocated sample were collected per sampling event. The VOC samples were collected over a 24-hour period starting at noon on the day before the CDH scheduled sampling day and ending at noon of the sampling day. The high-event monitoring program included sampling for 12 high-event days (Table 3.2-4) during all seasons of the year at stations AQ2, AQ3, AQ5, and AQ6, and at two mobile stations

when VOC emissions were expected to be highest and conditions for collection of compounds were most favorable (see Section 3.2.3.2). Variations to this sample site alignment were included in the program as appropriate. During each high event, sampling data, one trip blank, one field blank, and one collocated sample were also collected and analyzed. The collection and analytical methods for VOCs was certified by PMRMA/USATHAMA and incorporated modified methodological guidelines given in EPA Method TO-1, Compendium of Methods for the Determination of Toxic Organic Compounds in Ambient Air (EPA 1984).

The TO-1 method involved the use of a sorbent to trap VOCs that have a wide range of volatility. Method TO-1 employs Tenax GC adsorbent (poly [2,6-diphenyl phenylene oxide]) to trap organic species having a boiling point range of 80 degrees Celsius (°C) to 200°C. Each collected sample included three sorbent sections. The three sections included the following: a primary Tenax tube followed by a backup tube consisting of a Tenax section followed by a charcoal section. Analysis of the backup tube was performed on all of the samples in FY93. A more detailed discussion of the VOC field and laboratory analytical methods is provided in Section 4.6.7.

Additional VOC monitoring was performed quarterly using OVAs and OVMs on the Basin F waste pile vents and cap, Pond A, and around the tank vents. These real-time instruments were used at various locations as indicated in Table 3.2-2. Hydrogen sulfide and ammonia were also monitored using portable instruments.

The FID-type OVA (Foxboro OVA-128) detected flame-ionizable organic vapors at varying relative responses based upon calibration with methane span gas (sensitivity to certain compounds may vary depending upon their chemical composition). Concentrations were expressed as total ppm of organic vapor.

The PID-type OVM (HNU P101 or Thermo-Environmental 580B) nondestructively detected organic vapors that were ionizable by ultraviolet light. The PID responds to a wide variety of

organics including chlorinated hydrocarbons, heterocyclics, aromatics, aldehydes, and ketones (relative sensitivity to certain compounds may vary depending on their chemical composition). Concentrations were expressed as total ppm of organic vapor.

VOCs were also sampled quarterly using sorbent tubes at the four highest OVA/OVM vents on the Basin F waste pile, the highest Pond A vent, and three Basin F liquid storage tank vents. VOC sampling at the Basin A air stripper was performed weekly at Port B and monthly at Ports A, B, C, and D.

3.3.5 Semivolatile Organic Compounds and Organochlorine Pesticides

The SVOC methodology was adapted from EPA Method TO-4 and the OCP methodology is Method 608, EPA Test Method for Organochlorine Pesticides and Polychlorinated Biphenyls (PCBs) (both in EPA 1988b). The filter was Soxhlet extracted with 5 percent diethylether in hexane. The extract was concentrated using a Kuderna Danish apparatus. A gas chromatograph/electron capture detection (GC/ECD) system was used to determine aldrin, dieldrin, endrin, isodrin, DDT, DDE, and chlordane. Method certification for concentrations in air ranged from 0.263 to 5.26 nanograms per cubic meter (ng/m^3), based upon laboratory spike tests. Higher air concentrations could also be measured by diluting the sample extracts before analysis. The filters used for this method were pre-extracted in a Soxhlet apparatus before use. Filter blanks were analyzed to monitor background contamination.

The samples were collected using General Metal Works PS-1 samplers. In this method, ambient air was drawn through a quartz fiber filter and then through a polyurethane foam (PUF) sorbent section. The aeration target flow rate was 200 liters per minute (lpm).

OCPs were collected during a 24-hour period at stations AQ2, AQ3, AQ5, AQ6, AQ8, AQ9, FC1, FC2, FC5, SQ1 and SQ2 every 6 days as part of the baseline program. These routine OCP samples were collected starting at noon on the day before the CDH scheduled sampling day and ending at noon of the sampling day. OCPs were collected monthly at FC3 and FC4. OCPs and

SVOCs were collected at AQ2, AQ3, AQ5 and AQ6, and at two mobile sites, as appropriate, on high-event days (Table 3.2-3). Special weather situations or remedial activities dictated site selection for each high-event scenario. SVOCs were sampled on high-event days meeting the VOC/SVOC criteria or the alternative SVOC criteria (Table 3.2-5). The analytical methods for SVOCs and OCPs have been certified by PMRMA/USATHAMA.

3.3.6 Metals and Arsenic

Metals—including cadmium, chromium, copper, lead, and zinc, and arsenic, which is also a metal but is subject to a separate EPA method—were collected every 6 days at stations AQ2, AQ3, AQ5, AQ6, AQ8, SQ1, and SQ2, and every 12 days at FC1, FC2, and FC5 as part of baseline sampling for 24 hours starting at midnight of the CDH scheduled sampling day. Metals and arsenic were collected monthly at stations FC3 and FC4. Samples were also collected at stations AQ2, AQ3, AQ5, AQ6 and at two mobile stations during 12 high-event periods (see Table 3.2-4) using Hi-Vols and/or personal sampling pumps. Analytical methods have been certified by PMRMA/USATHAMA.

The collection methodology for metals followed the EPA method for lead determination, Reference Method for the Determination of Lead in Suspended Particulate Matter Collected from Ambient Air, 40 CFR Appendix G. The analytical methodology for determination of arsenic followed EPA Method 206.2, while determination of the remaining metals was adapted from the NIOSH Method 7300 for elements in air using ICAP emission spectrometry.

3.3.7 Mercury

Mercury was monitored every 6 days at stations AQ2, AQ3, AQ5, AQ6, AQ8, SQ1, and SQ2 (Table 3.2-2). Samples were taken for 24 hours starting at noon on the day before the CDH scheduled sampling day. The same high-event days used for metals and arsenic sampling were used for mercury sampling (Table 3.2-4). The high-event samples were usually taken over a 24-hour period. Portable sampling stations were positioned according to wind direction.

Hydrar tubes (manufactured by SKC, Inc.) were used for sampling. Analysis was performed according to the Rathje and Marcero method (Rathje and Marcero 1976).

3.3.8 Ammonia

Real-time monitoring for ammonia was conducted at the Basin F waste pile vents, restored basin cap, waste pile cap, Pond A, and Basin F liquid storage tanks (Table 3.2-3). The ammonia analyzer (Analytical Technologies Inc., Model A16-15) was selectively sensitive to ammonia vapors in air. It utilized an electrochemical sensor that registers electrical change in proportion to the concentration of ammonia sample gas.

3.3.9 Hydrogen Sulfide

Real-time monitoring for hydrogen sulfide was conducted at the Basin F waste pile vents, restored basin cap, waste pile cap, Pond A, and Basin F liquid storage tanks as shown in Table 3.2-3. The hydrogen sulfide analyzer (Jerome 631X, 1 part per billion (ppb) to 50 ppm) is highly selective and eliminates interference from sulfur dioxide, carbon dioxide, carbon monoxide, and water vapor. It utilizes a gold film detector that registers a change in electrical resistance in proportion to the concentration of hydrogen sulfide in the sample gas.

3.4 CONTINUOUS AIR MONITORING PROGRAM

Primary pollutants, as defined by the EPA, include nitrogen dioxide, carbon monoxide, sulfur dioxide, ozone, TSP, PM-10, and lead. Methods and procedures for TSP, PM-10, and lead sampling have already been discussed. The remaining four pollutants are gases, which were monitored continuously at ambient levels rather than concentrated in sample media for subsequent analysis in a laboratory. Therefore, procedures associated with collecting, handling, preserving, storing, shipping, and analyzing samples were not applicable. However, an equally complex set of procedures was required to ensure that the monitored data were acceptable. The SOPs contained procedures for the calibration, operation, maintenance, quality assurance, and data analysis for this aspect of the CAQMMP (EBASCO 1992). Additional activities included procurement and installation of equipment and operational checkout of procedures and equipment.

A summary of basic elements of the primary pollutant gaseous monitoring program is discussed below.

The continuous analyzers were housed in a temperature-controlled monitoring station approximately 12 feet wide by 16 feet long. The site was adjacent to M4, located in the southwest corner of Section 25 (Figure 3.5-1). It contained a receiver for the radio-telemetry of three remote meteorological stations; a fourth meteorological tower was adjacent to the building. A data logger collected and processed all of the meteorological and continuous gaseous monitoring data.

The continuous gaseous monitoring station contained an EPA-designated reference or equivalent method analyzer for each parameter, an approved glass sample intake manifold system, a digital data recording system, strip chart recorders, and calibration equipment. The calibration system automatically tested the zero and span (near full-scale) responses of each analyzer on a daily basis to verify proper operation. The station operator visited the station at least 3 days per week to conduct numerous checks to further verify proper operation of all instrumentation. Audits were performed quarterly, not only of the continuous monitors installed in this station, but also of all the TSP and PM-10 samplers installed around RMA.

The detection method employed by each of the analyzers was as follows:

- Nitrogen dioxide—chemiluminescence
- Carbon monoxide—gas filter correlation
- Sulfur dioxide—pulsed fluorescence
- Ozone—ultraviolet photometry

Specific equipment and instrumentation prescribed for the program were as follows:

- Nitrogen dioxide and oxides of nitrogen—Teco 14 B/E Analyzer, 0 to 0.5 ppm (EPA Approval RFNA-0179-035)
- Carbon monoxide—Teco 48 CO Analyzer, 0 to 50 ppm (EPA Approval RFCA-0981-059)
- Sulfur dioxide—Teco 43A Analyzer, 0 to 0.5 ppm (EPA Approval EQSA-0486-060)
- Ozone—Teco 49 03 Analyzer EPA, PSD, 0 to 1.0 ppm (EPA Approval EQOA 0880-047)
- Calibrator—Teco 146, Dilution System with GPT Teco 111 Zero Air Supply
- Inlet Manifold—aspirated glass manifold system, 25 millimeter
- Data Acquisition System—Digital data logger with memory and output interface
- Calibration support equipment—National Institute of Standards and Technology (NIST) traceable flow, temperature, and gas certification

The station was designed in full accordance with the following four EPA documents:

- 40 CFR 58, Appendix B—Quality Assurance Requirements for Prevention of Significant Deterioration (PSD) Air Monitoring (1985)
- Ambient Monitoring Guidelines for Prevention of Significant Deterioration (EPA 1987)
- Quality Assurance Handbook for Air Pollution Measurement Systems, Volume I Principles (EPA 1984)
- Quality Assurance Handbook for Air Pollution Measurement Systems, Volume II Ambient Air Specific Methods (EPA 1985)

3.5 METEOROLOGICAL MONITORING PROGRAM

Meteorological parameters were monitored at four locations within RMA's boundaries. Three stations were established in 1981 and were maintained by RMA. During CMP FY89, a modification to the Technical Plan placed meteorological monitoring and data processing under CMP responsibilities. The network was upgraded to include radio-telemetry from the three original sites to a central computer facility, which was also the location of the continuous gaseous monitoring site. A fourth meteorological station was erected at this location. Operation of the

upgraded meteorological network was initiated on February 1, 1989, and continued through FY93. Results of the meteorological monitoring program are provided in Section 6.0, and detailed data are shown in Appendix J.

3.5.1 Location of Meteorological Monitoring Stations

The separate meteorological monitoring sites were set up to be as close as possible to potentially major sources of contaminants at RMA. These sites are indicated as M1, M2, M3, and M4 (Figure 3.5-1). Meteorological Station 1 (M1) was located in Section 26, approximately 200 yards south of Ninth Avenue and 700 yards west of "D" Street. Meteorological Station 2 (M2) was located in Section 25, north of the North Plants complex, approximately 200 yards south of Ninth Avenue and 700 yards east of "D" Street. Meteorological Station 3 (M3) was located approximately 50 yards north of December Seventh Avenue and 500 yards west of "E" Street in Section 36. Meteorological Station 4 (M4) was located approximately 15 yards north of Eight Avenue and 350 yards east of "D" Street in Section 25. The meteorological monitoring stations were previously installed to depict potential local and micrometeorological influences that may occur on RMA. One of the objectives of the CAQMMP has been to analyze the collected data and determine air quality impacts, if any, that may result from local topographical differences and the resultant drainage differences on RMA. Results of this analysis are included in this report.

3.5.2 Monitoring Equipment and Strategy

Monitoring sensors were fixed on 10-m meteorological towers or at the base of the stations. Wind speed, wind direction, sigma theta, temperature, and relative humidity were monitored at 10 m above ground level while solar radiation, barometric pressure and precipitation were all monitored at the surface. Temperature was monitored at M1 at both the 10-m and 2-m levels, and the temperature difference between the two sensors was calculated. A depiction of parameters monitored at each site is shown in Table 3.5-1.

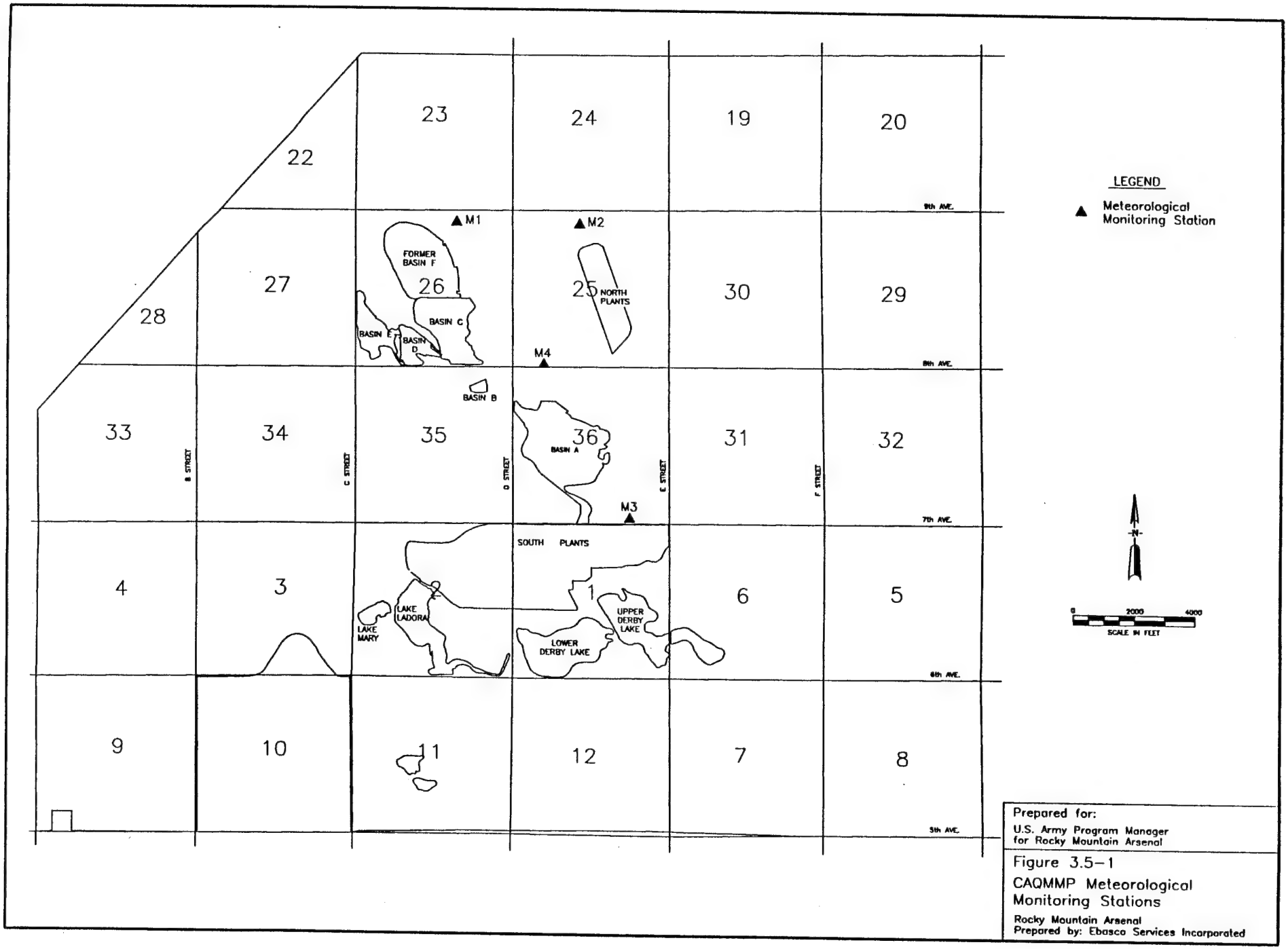

LEGEND
Meteorological Monitoring Station
M1
M2
M3
M4
FORMER BASIN F
BASIN E
BASIN D
BASIN C
BASIN B
BASIN A
NORTH PLANTS
SOUTH PLANTS
LAKE MARY
LAKE LADORA
UPPER DERBY LAKE
LOWER DERBY LAKE
B STREET
C STREET
D STREET
E STREET
F STREET
9th AVE.
8th AVE.
7th AVE.
6th AVE.
5th AVE.
0
2000
4000
SCALE IN FEET
Prepared for:
U.S. Army Program Manager for Rocky Mountain Arsenal
Figure 3.5-1
CAQMMP Meteorological Monitoring Stations
Rocky Mountain Arsenal
Prepared by: Ebasco Services Incorporated

Table 3.5-1 Meteorological Parameters Monitored at RMA During FY93 Page 1 of 1

	Site			
Parameter	M1	M2	M3	M4
Wind Speed	X	X	X	X
Wind Direction	X	X	X	X
Sigma Theta	X	X	X	X
Temperature (10-meters)	X	X	X	X
Temperature (2-meters)	X			
Relative Humidity	X			
Barometric Pressure				X
Solar Radiation			X	
Precipitation	X	X	X	X

3.5.3 Data Acquisition

Meteorological data were downloaded automatically each night from each site onto the base computer through telemetry, modems, and phone lines. This database was closely checked each day by CAQMMP personnel.

3.5.4 Data Applications

Meteorological data were used in several ways during the CAQMMP. Wind speed, wind direction and temperature were used to select sampling days and identify high event periods favorable for collection of contaminants. Temperature and barometric pressure were employed to compute standardized volumes for air quality data. All parameters, including atmospheric stability and precipitation data, were collected and correlated with long-term regional data in order to determine the representativeness of the sampling period. The various meteorological parameters were employed to compare the data monitored with potential source impacts as predicted by atmospheric dispersion models.

3.6 CHAIN-OF-CUSTODY

Chain-of-custody forms were completed and accompanied all samples from pre-sampling preparation through sampling and analyses. The data on the forms included the sample number, the parameter being sampled, site location, date sampled, project name, project number, and signatures of those in possession of the samples.

3.7 LABORATORY ANALYSIS PROGRAM

The objective of the laboratory analysis program was to provide PMRMA with reliable, statistically supportable, and legally defensible air quality data for airborne materials sampled at RMA. As noted in the previous section, laboratory analysis methods (except those for TSP, PM-10, and asbestos) were reviewed and certified by PMRMA. VOCs and SVOCs were analyzed by certified semi-quantitative GC/MS methods (the analyte concentrations are calculated based on internal standard response in the sample). OCPs (aldrin, dieldrin, endrin, isodrin, PPDDE and PPDDT), ICAP metals (cadmium, chromium, copper, lead, and zinc) and other

metals (arsenic and mercury) were analyzed by certified quantitative methods. TSP, PM-10, and asbestos analyses were determined using standard NIOSH and EPA analytical methods.

The target analytes for the program were selected from an evaluation of contaminant sources at RMA, the compounds associated with previous activities at these sites, and compounds previously detected in past air, soil, and water monitoring investigations. Table 3.7-1 lists the analyses, along with the type of certification procedure, the reference method, and the type of analytical method.

The defensibility and technical quality of data generated in this program were assured by documenting all the analytical procedures and by requiring all data to exceed minimum analysis method requirements with respect to instrument calibration and quality control. Sample preparation, materials shipping, handling, and chain-of-custody procedures followed the protocol outlined in the Quality Assurance Project Plan (Ebasco 1992b).

For each target compound, there is a lower certified reporting limit (CRL). This CRL refers to the lower detection limit of the analytical technique that can assure a 95 percent confidence limit of positive detection. The CRL is based on a mass per sample and is limited by instrumentation and methodology. (Below this limit, any detection must be regarded as not detected or below the CRL.) Table 3.7-2 lists the compounds and groups of compounds along with their lower CRL. Note that within the VOC and SVOC groups, there is a wide range of lower CRLs, which vary according to target analyte sensitivity in relation to the method employed. Table 3.7-2 also provides detection limits converted to atmospheric concentrations based on the reported lower CRL and an estimated target volume for each sample group.

There is also an upper certified reporting limit for each target compound. The lower and upper CRL volumes define the accepted linear range for each target analyte, and is limited by instrumentation and methodology. Any detection above the upper CRL must be labeled as an estimated value since it falls outside of the certified range.

Table 3.7-1 Analytical Methods for Air Quality Monitoring Program

Parameter	Certification	Reference Methods	Certification Method	PMRMA Method Number
TSP	None	40 CFR Part 50, Appendix B	Gravimetric	
PM-10	None	40 CFR Part 50, Appendix J	Gravimetric	
Asbestos	None	NIOSH 7400	Phase Contrast Microscopy	
VOC	Semi-quantitative	Modified EPA TO-1 with EPA Method 624	GC/MS[I]	CM04
SVOC	Semi-quantitative	Modified EPA Method TO-4	GC/MS	CM03
OCP	Quantitative	Modified EPA Method 608	GC/ECD[II]	CH01
Metals	Quantitative	NIOSH 7300	ICAP[III]	AS01
Lead	Quantitative	40 CFR Part 50, Appendix G	ICAP	
Arsenic	Quantitative	EPA Method 206.2, 1979	AA[IV]-Graphite Furnace	AD03
Mercury	Quantitative	AIHA, 1976	AA-Cold Vapor	AB01

I GC/MS Gas Chromatography Mass Spectrometry
II GC/ECD Gas Chromatography Electron Capture Detection
III ICAP Inductively Coupled Argon Plasma Emission Spectrometry
IV AA Atomic Absorption

Table 3.7-2 Analytes and Certified Reporting Limits for Air Quality Monitoring Program

Parameter	Certified Reporting Limit (Lower Certified Range)	Atmospheric Detection Limit
TSP	100 µg*	0.1 µg/m^3
PM-10	100 µg*	0.1 µg/m^3
Asbestos	7 fibers/mm^2	0.001 fibers/ml
VOC	0.012 to 0.160 µg	0.056 - 0.741 µg/m^3
OCP	0.100 µg	0.0003 µg/m^3
SVOC	5.0 µg to 40.0 µg	0.0174 - 0.1389 µg/m^3
Metals		
cadmium	4.0 µg	0.0025 µg/m^3
chromium	20.0 µg	0.0123 µg/m^3
copper	10.0 µg	0.0061 µg/m^3
lead	40.0 µg	0.0245 µg/m^3
zinc	20.0 µg	0.0123 µg/m^3
Arsenic	1.41 µg	0.0009 µg/m^3
Mercury	0.10 µg	0.2315 µg/m^3

* = Limit is not certified, but is instrument and method dependent.

OCP - Organochlorine Pesticides
PM-10 - Particulate Matter Less Than 10 Micrometers
SVOC - Semivolatile Organic Compounds
TSP - Total Suspended Particulates
VOC - Volatile Organic Compounds
µg - microgram
mm - millimeters
ml - milliliter
µg/m^3 - Microgram per cubic meter

3.8 DOCUMENTATION

All activities and data collected under the CAQMMP are thoroughly documented in annual reports (RLSA 1989, 1990, 1991; WCC 1992, 1993); data are also maintained in the Installation Restoration Data Management Information System (IRDMIS). In addition, all fixed mobile monitoring sites have been surveyed to accurately determine sampling locations (see Table 3.2-1).